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The Osteology of the Lacertilia.

By E. D. Cope.

(Read before the American Philosophical Society, March 18, 1892.)

In the following pages is presented a review of the osteology of the Lacertilia with especial reference to the genera represented in the Nearctic fauna. It is based on the skeletons placed at my disposal by the U. S. National Museum, the Academy of Natural Sciences, and those contained in my private collection. It includes also the record of my observations and notes made in the principal European museums twenty-five years ago. The characters discovered by me at that time, which I found to be of the greatest taxonomic importance, I enumerated in a paper which is printed in the Proceedings of the Philadelphia Academy for 1864, p. 224. The use then made of those characters has been generally accepted by subsequent writers.* There are, however, many other characters whose value is of uncertain taxonomic value, which were not then mentioned, and which I now record.

The first description of the osteology of the Lacertilia is that of Cuvier, which is contained in his *Ossements Fossiles*; (Vol. x, ed. 1836). This is an excellent one, but the many types discovered since his time render it necessary that a new survey of the subject should be made. In 1836 the *Zootomie der Amphibien*, by Stannius, appeared. The account of the osteology of lizards given in this work is more complete than that of Cuvier, but it is incomplete in many points, and is not up to the requirements of the present time. The present study is made with especial reference to the necessities of the paleontology of the order; therefore the description of characters is made as specific as possible. The principal novelty will be found in the references to North American Genera, and in the descriptions of the hyoid apparatus. The description of the scapular and pelvic arches in certain genera with the extremities degenerate or wanting, where they have not been previously described, is contained in a separate illustrated paper now in the hands of the editor of the *American Journal of Morphology* for publication.

SKULL.—The premaxillary bone is single except in the Scincidæ, Acontidæ, and some Geconidæ (*Phyllurus* sp.). It is very small in the Iguanid genus *Phrynosoma*, and in the Agamidæ it is excluded from contact with the vomer by processes of the maxillaries which meet on the middle line. In the Chamæleonidæ the premaxillary is still smaller, the body being narrower than the superior spine, and supporting but one tooth. In the Anguidæ the premaxillary is bounded posteriorly on each side by a foramen which is sometimes large, which is wanting in other families, including the Helodermidæ. In *Lepidosternum* it is principally on the inferior

* See Boulenger, *Ann. Magaz. Nat. History*, 1884, p. 117; and *Catalogue of Lizards in British Museum*, i, 1885; ii, 1885; iii, 1887. This author has added osteological characters of the Eublepharidæ, Uroplatidæ, Pygopodidæ and Dibamidæ.

face of the muzzle. The nasal bones are generally distinct, but in the *Varanidæ* they are fused into a single narrow median element. In the *Chamæleonidæ* they do not attain the nasal border, being cut off by the junction of the prefrontal with the premaxillary and maxillary bones. In the genus *Feylinia* the nasal bones are fused into a broad plate. In *Lepidosternum* they are completely cut off from the nasal border by the maxillary, which is broadly in contact with the premaxillary spine. In *Rhineüra* the nasal bone reaches the nares as in *Amphisbæna*. The frontal bones are separate in the *Varanidæ*, *Helodermidæ*, *Anguidæ*, *Scincidæ*, *Anelytropidæ*, *Anniellidæ* and *Amphisbænidæ*, and in some *Geconidæ*. They are coössified in some *Geconidæ*; in the *Iguanidæ*, *Agamidæ*, *Xenosauridæ*, *Eublepharidæ*, *Chamæleonidæ* and *Tiidæ*. The parietals are generally fused, the only exception being the *Geconidæ*, *Uroplatidæ*, and *Xantusiidæ*. Prefontals are always present, and in *Anniellidæ*, *Helodermidæ* and *Chamæleonidæ* they extend posteriorly to the postfrontals, excluding the frontal from the orbital border. Lachrymals are present, but they are fused with the prefrontal in the *Scincidæ*. The jugal is generally present, even when there is no postorbital arch, as in *Geconidæ*, where it is a splint; but in the *Amphisbænia*, *Annielloidea*, and in *Feylinia*, the splint-like element attached to the maxillary extends to the pterygoid posteriorly and the prefrontal anteriorly, and may include the lachrymal. The jugal extends anteriorly as far as the lachrymal except in the *Scincidæ*. The postfrontal is wanting and in most cases is fused with the postorbital in the *Varanidæ* and *Agamidæ*; but in other families it is distinct, with sporadic cases of fusion, as in *Cnemidophorus*. Superciliary bones are present in *Varanus*, *Phrynosoma* and several genera of *Agamidæ*. They belong to the tegumentary system, and articulate, the anterior with the prefrontal, the posterior (absent in *Varanus*) with the postfrontorbital bone. The supraoccipital is undivided and forms the superior part of the edge of the foramen magnum. Its anterior border is generally loosely articulated with the parietal, joining it by a rudimental or developed median gomphosis with the process supraoccipital. It is generally overhung by the parietal, always so when the parietoquadrate arches are present. It is entirely overroofed by the parietal in the *Xantusiidæ*, the two elements being connected by a vertical laminiform septum. It is not overhung in the *Annielloidea* and *Amphisbænia*, and in these the articulation is a firm complete transverse union. The parietoquadrate arch consists proximally of a process of the parietal, which is directed outwards and posteriorly, which may represent the supramastoid element of the primitive *Cotylosauria*. Distally this process receives an ascending process of the paroccipital on its inferior aspect, sometimes anteriorly, sometimes posteriorly. This arch is shortened and depressed in the *Anelytropidæ* and is absent from the *Anniellidæ* and *Amphisbænia*. In the *Chamæleonidæ* it is differently composed, consisting of a superior posterior process of the supratemporal, which rises upwards and reaches the produced apex of the

undivided parietal. The supratemporal is accompanied for a short distance above the quadrate by the ascending process of the paroccipital. The pineal foramen is present in the Chamæleonidæ, Agamidæ, Iguanidæ, Anolidæ, Xenosauridæ, Anguidæ, Lacertidæ, Varanidæ and Scincidæ. It is wanting in the Helodermidæ, Eublepharidæ, Tiidæ, Anniellidæ and in the Amphisbænia. It perforates the parietal bone clear of all sutures in most of the families, but it is near to or on the frontoparietal suture in Iguanidæ and Anolidæ, and is in the frontal in Dipsosaurus and the Chamæleonidæ. The occipital condyle is compound, consisting of portions of the exoccipitals and basioccipital. In many genera these segments become so thoroughly coössified at maturity as to be undistinguishable. In some of the Geconidæ (as Gecco, Uroplates) the occipital segment is so reduced as to give the appearance of two condyles. In the Amphisbænia the condyle is transverse and concave at the center, leaving the lateral portions prominent.

The postorbital bone when present sends a process posteriorly to the supratemporal, forming the supratemporal arch. In the genera without this arch the postorbital may be wanting, as in *Heloderma*, or be rudimental as in *Anniella*. In the genera whose degeneration is advanced, the supratemporal bone is appressed to the parietal, enclosing no *foramen supratemporale*, as in *Feylinia*. In limbless genera of Anguidæ the supratemporal touches the parietal anterior to the paroccipital, thus reducing the supratemporal foramen. This occurs also in *Gerrhonotus*, *Celestus*, *Xenosaurus* and *Xantusiidæ*. In *Heloderma* the supratemporal is a rudiment on the external side of the base of the paroccipital.

The remarkable upward production of the supratemporal in Chamæleon has been mentioned. Here this process takes the place of the parieto-quadrate arch. The exoccipitals are produced laterally, each embracing, with the petrosal in front, the small paroccipital. This sustains the superior extremity of the quadrate. In the snake-like genera, as *Feylinia*, *Anniella* and the Amphisbænia, this lateral elongation does not exist. The exoccipital is scale-like, and the quadrate is sessile on the side of the skull. The quadrate is generally convex at the upper part of its anterior face, and its external anterior border is produced outwards so as to embrace a longitudinal concavity or conch, with the vertical mass or column of the bone. This column is itself more or less concave, its upper extremity being produced a little backwards. In the Iguanidæ there is another concavity, internal to the column, similar to the external. This is much narrowed in the majority of the families, and in the Varanidæ and Helodermidæ, and in *Phrynosoma*, *Eublepharis*, and *Celestus* it is wanting. In Chamæleon, *Anniella* and the Amphisbænia there is no external conch, the quadrate being simply a rod; while in *Feylinia* it is flattened in an anteroposterior plane. The mandibular articulation is more or less bilobate in all except *Varanus*, where it is plane. In *Gecco* the bilobation is strongly marked, as in the Permian Theriodonta. The pterygoid bones extend forwards from the quadrates, with which they are

in contact in all forms except *Chamæleon*, towards the middle line. This portion is generally grooved, but in *Xenosaurus* it is a slender rod. They are received on the basipterygoid processes of the sphenoid, and then diverge and assume a longitudinal position without meeting on the middle line. They are produced in an angle or process towards the posterior extremity of the maxillary bone, from which they are separated by the ectopterygoid. The pterygoids then join the palatines. In a few genera they bear a few small teeth. The palatines are separate from each other and from the maxillaries, but send a process outwards and forwards to the latter. They join in front each its corresponding half of the vomer. The internal nares are situated each between the vomer and the maxillary, and it notches more or less deeply the palatine, which forms its posterior border. The vomers are separate in all forms excepting *Chamæleon*, and they have various forms. In *Geconidæ* and *Anolidæ* they are flat and fit closely together, and they have the same character in many *Agamidæ* and *Iguanidæ*. In a few members of these families (*Uromastix* and *Sauromalus*), they are divided by a groove, which becomes a fissure posteriorly, which is the character in most other lizards. In the *Varanidæ* each vomer is produced posteriorly on each side this fissure to a greater distance than in other forms. The planes of the palate differ much in different families and groups. Thus the vomer is on a much higher plane than the palatines in *Chamæleonidæ* and *Geconidæ*, the palatines curving downwards to meet the pterygoids. The latter are generally horizontal, but in *Chamæleon* they are in a subvertical plane, their free rounded extremities descending and fitting on the inner side of the mandible. They do not quite reach the quadrate. In the *Agamidæ*, *Iguanidæ* and *Geconidæ* the internal extremity of the ectopterygoid is directed inferiorly, forming a downwardly directed angle on each side of the palate. In the *Amphisbænia* the structure of the palate is much more compact than in other lizards. The palatines are in contact on the middle line and there is no palatamaxillary foramen. That is, the palatine is in close contact with the maxillary, the ectopterygoid being tightly wedged in between them. The pterygoids are in contact throughout their length with the sphenoid, and the proximal end of each is tightly wedged between the latter and the quadrate.

The character of the petrosal must be attended to by any one who desires to understand the relations of the *Lacertilia* among themselves. In no member of the *Lacertilia* is the trigeminus foramen closed anteriorly by bony tissue, but it is enclosed by the membrane which forms the anterior wall of the brain case. The petrosal is divided into two parts by the deep notch whose fundus forms the posterior border of this foramen, which may be called the supra- and infraforaminal portions. The infraforaminal portion is divided in most of the families by a longitudinal, keel-like ridge, which forms the superior border of a groove whose inferior wall is formed by the sphenoid. This groove is not present in *Heloderma* and is very shallow in *Xenosaurus*. It is wanting in the *Anniel-*

lidæ and Amphisbænia. In the Geconidæ it does not exist, nor is the petrosal notched by the foramen, while the anterior border of the petrosal forms a free crest which extends from above downwards and backwards. In the Chamæleonidæ, Agamidæ, Iguanidæ and Anolidæ (families with papillose tongues), the supraforaminal part of the petrosal is short and is bounded by a convex anterior border which marks the position of the anterior semicircular canal. In the Nyctisaura, Thecaglossa, Diploglossa, Leptoglossa and Amphisbænia (families with smooth or squamous tongues, except Anniella, Diploglossa and Nyctisaura) the petrosal is produced beyond this curved border below the parietal. In many forms an outline of the semicircular canal, which forms the boundary in the other superfamilies, may be traced, whence I have termed this part of the petrosal posterior to it "the arched body" in my former system of the Lacertilia.* The petrosal is produced furthest beyond this arcade in the snakelike forms of the Anniella and Amphisbænia, reaching almost to the orbit in *Lepidosternum*. The relation to the parietal differs, the differences resulting from the greater or less reduction of the primitive supratemporal roof and the greater or less entrance of the parietal into the lateral wall of the brain case. In most of the families it is little or not decurved to meet the petrosal; and in the *Iguania*, where it is decurved, it does not come in contact with the petrosal owing to the shortness of the latter. In certain families where the petrosal is produced beyond the arcade, and the parietal is decurved, the two elements are in contact for a short distance, as in the *Varanidæ*. In the *Tiidæ* and *Scincidæ* the contact is mainly effected by a short descending process of the parietal. This process is especially elongate in the *Scincidæ*. The arcade is the anterior border of the petrosal in the Permian *Theriodonta*, and it marks the position of the anterior semicircular canal. The membranous wall of the brain case, anterior to the petrosal, contains an ossification which is of uncertain homology. It reaches or approaches by its superior extremity the frontal, and might hence be supposed to be the orbitosphenoid; but this homology is vitiated by the fact that its inferior portion passes behind the optic foramen. The latter position is that of the alisphenoid, and so the bone is named by Parker.† But there is another element, the epipterygoid, posterior to it and immediately anterior to the petrosal, which has been supposed to be the true alisphenoid. Leaving this question, and adopting for the bone in question the provisional name of postoptic, I remark that it is typically triradiate, sending two branches upwards and one downwards. This is its character in *Agamidæ*, *Varanidæ* and *Tiidæ*. The posterior superior branch is much reduced in many *Iguanidæ* and *Lacertidæ* and in some *Agamidæ* (*Megalochilus*), and it is absolutely wanting in *Gerrhosaurus* and *Chamæleon*. There is nopostoptic in *Heloderma*. In the *Rhynchocephalian* genus *Sphenodon* these two elements coexist with an orbitosphenoid, lying between the optic and tri-

* Proceeds. Academy Philadelphia, 1864, p. 224.

† Transac. Royal Society, 1879, p. 605, on the "Development of the Skull in Lacertilia."

geminal foramina. The two together may be homologous with the mammalian alisphenoid. The epipterygoid is present in all Lacertilia excepting the Chamæleonidæ and Annulati (Amphisbænia). Its superior connections are quite characteristic of the different families. Inferiorly it rests on the pterygoid posterior to its ectopterygoid process, excepting in the Geconidæ, where its point of attachment is opposite to that process. In the same family it does not reach the parietal, but the superior extremity rests on the apex of the supraforaminal part of the petrosal. In the remaining families there are three modes of superior attachment. In most of the Iguania and Acrodonta it reaches the parietal and does not touch the short petrosal. In the other superfamilies it is in contact with the petrosal. In the Varanidæ, Helodermidæ and most Anguidæ it reaches the parietal, which does not meet it with a conspicuous descending process. In Scincidæ and Tiidæ a conspicuous descending process meets it. In a certain number of genera of various families it does not quite reach the parietal. Such are Eublepharidæ, Gerrhosauridæ, Anguis, Lacerta, Phrynosoma (where it rests on the arcade of the petrosal), Iguana, Uromastix, Agama and Gonyocephalus (*suberistatus*). In Lyriocephalus and Phrynocephalus the epipterygoid is very short.

The *semicircular canals* perforate the supraoccipital, the exoccipital and the petrosal. The internal is in a subtransverse vertical plane, causing a convexity on the internal side of the supra- and exoccipitals, and in some types a visible rib on the superoexternal surface of the same. The external canal is in a horizontal plane and perforates the base of the exoccipitopetrosal suspensorium, causing a horizontal rib on the anterior face of the latter in some forms. The anterior is in a vertical anteroposterior plane, and perforates principally the petrosal, occupying its anterior border, which forms the "arcade" in most of the thick-tongued superorders, but crossing the bone much behind the anterior border in the slender-tongued superorders and the Diploglossa. The *fenestra ovale* is tightly closed by the disk of the stapes, which is continued externally as the rod-like columella. This rod is slender except in Anniella, where it is remarkably robust. In the other Amphisbænia its tympanic extremity is somewhat thickened. The columella is continued externally into a cartilage which is more or less expanded in the vertico-transverse plane, the distal portion always so, forming a vertical lamina in contact with the tympanic membrane. This is the epistapedial cartilage. It is frequently produced upwards beyond its point of attachment into a suprastapedial process. The plate thus formed is almost separate from the proximal axial part of the cartilage in Heloderma.* The axial portion has a descending process, the infrastapedial of Parker, in Lacerta, Heloderma, but not in Eublepharis, Thecadactylus and Phyllodactylus.

The rami of the *lower jaw* are united at the symphysis by ligament only. The angle is a prolongation of the articular bone; it is elongate and simple,

* Memoirs U. S. Natl. Academy Sciences, 1884, Vol. iii.

except in *Anniella* and *Chamæleon*, where it is absent. The angular bone never reaches the angle, and has an anterior position, being sometimes fused with the articular. The relations of the segments of the lower jaw are very characteristic in the divisions of the *Lacertilia*. The splenial bone is wanting in the *Chamæleonidæ*, and is very small in the *Agamidæ*; in other families it is well developed. The dentary extends posteriorly on the external face of the ramus, as the splenial diminishes, having the greatest posterior extent in the two families mentioned. The coronoid is differently extended in a similar ratio. Thus it is extended posteriorly on the external side of the ramus, and not anteriorly, in the *Chamæleonidæ* and *Agamidæ*; both forwards and backwards in the *Geconidæ*; and forwards in the other families. The angular is absent (fused with the articular Boulenger) in the *Geconidæ*, *Anolidæ*, *Acontiidæ*, *Anelytropsidæ*, *Anniellidæ* and the *Annulata*, and is distinct in all other families. The articular and surangular are fused in several genera of *Iguanidæ*; and there are but three bones in the ramus of *Xantusia*, q. v. The angular extends well anteriorly on the inferior border of the jaw in this order, but is differently developed on the inner and outer faces. The *Chamæleonidæ* and *Agamidæ* again show their similarity in having this element chiefly exposed on the interior side, while in other types the exposure is external. The Meckelian groove is open in the *Chamæleonidæ*, *Agamidæ* and *Varanidæ*, but is roofed over more or less completely in all other families.

The *hyoid system* is not connected with the skull except in *Geconidæ*, *Eublepharidæ* and *Lepidophyma*, so far as I have examined them. Thus in *Thecadactylus*, *Phyllodactylus* and *Eublepharis*, the ceratohyal is continuous with a cartilage which projects from the paroccipital above the posterior part of the auditory meatus. In *Lepidophyma* the free epibranchial is attached to the inferior lateral angle of the basioccipital. In forty-two genera of other families enumerated below, this is not the case. In no genus have I discovered any connection with the stapedial cartilages. The hyoid system in lizards consists of a glossohyal which is continuous with a basihyal tract; a hypohyal often continuous with the basihyal tract; a ceratohyal; a first ceratobranchial, and a second ceratobranchial which is always continuous with the basihyal tract. There may be in addition an epibranchial, which belongs to the first ceratobranchial. In some genera, there is a free epibranchial, which may be then closely approximated to the ceratohyal (*Eumeces*, *Oligosoma*, *Gerrhonotus*), or to the second ceratobranchial (*Lacerta*, *Xantusia*, *Lepidophyma*). The only constantly ossified element is the first ceratobranchial. The genera and families differ in the presence or absence of the second ceratobranchials and epibranchials; and the proximity or separation of the former. In general the *Varanidæ*, *Anguidæ*, *Zonuridæ*, *Gerrhosauridæ*, *Scincidæ*, *Lacertidæ* and *Xantusiidæ* have epibranchials, while the thick-tongued and most degraded types are without them. In the *Tiidae* the hypobranchials are much produced anteriorly beyond the bases of the ceratohyals, and there are no second ceratobranchials. In *Anguidæ* the

hypobranchials are also greatly produced forwards, but carry the ceratohyals with them. Ceratobranchials of the second pair are also wanting in Varanidæ, Helodermidæ, Chamæleonidæ, Anguidæ, Anniellidæ and Rhineura; Phyllodactylus, Thecadactylus and Gecko, among Geconidæ; and Egernia and Gongylus in Scincidæ. Ceratohyals are wanting in Chamæleon, Anguis, Anniella and Annulata generally. In both Agamidæ and Iguanidæ the second ceratobranchials are separated from each other in the depressed genera of terrestrial habits, and in close contact with each other in those of arboreal habits; but they are in close contact in Callisaurus and Crotophytus, both terrestrial genera. In Calotes, Iguana and Anolis they act as the rim on which the gular pouch or fan is stretched. The characters of Lacertilian hyoids may be tabulated as follows: Most of the genera referred to are figured in Plates iii to vi.

I. Ceratohyal present.

II. Ceratohyal absent.

A. A second ceratobranchial.

a. Free epibranchials present.

Scincidæ.

Lacertidæ.

Xantusiidæ.

aa. No free epibranchials.

(Scincidæ) *Mabuia agilis*; *Gongylus ocellatus*.

Anolidæ.

Iguanidæ.

Agamidæ.

Zonuridæ.

Eublepharidæ.

(Geconidæ) *Aristelliger*.

Chirotidæ.

Amphisbænidæ.

AA. No second ceratobranchial.

a. No free epibranchials.

Geconidæ.

Varanidæ.

Helodermidæ.

Rhineura.

Chamæleonidæ.

Tiidæ.

Gerrhosauridæ.

Anguidæ.

Anguis.

Anniellidæ.

2. VERTEBRAL COLUMN.—Except in the families of the Geconidæ and Uroplacidæ, the vertebral centra are procœlous. In the families named, they are amphicœlous. The zygosphen articulation is present in the Tiidæ and the larger Iguanidæ, including a rudiment in Crotaphytus. In smaller Iguanidæ (*Sceloporus Phrynosoma*) and in Lacertilia generally this kind of articulation is wanting. In a good many families the caudal vertebræ are divided by a transverse fissure or suture in front of the middle, which

often splits the base and sometimes the length of the diapophysis. Such a structure is seen in Iguanidæ (*Iguana Sauromalus Sceloporus Diposaurus*); Anolidæ; Anguidæ (*Celestus*); Tiidæ (*Tupinambis Cnemidophorus*); Lacertidæ (*Lacerta*) and Scincidæ (*Gongylus Eumeces*). In *Dipsosaurus*, *Anolis* and *Lacerta*, the neural spines of the caudal vertebræ are double; in the other genera named, single. In Varanidæ, Helodermidæ, Gerrhonotus, Crotaphytus and Phrynosoma, the caudal centra are undivided, and the neural spines are single. In *Ophisaurus* the centra are undivided and the neural spines double. The centra are excessively thin in *Ophisaurus*, so that they break more readily than they disarticulate. There are two sacral vertebræ except in genera with the posterior limbs rudimental or absent. In some of these however, especially the degenerate genera of the Anguidæ, the rudimental ilium is attached to two diapophyses which join each other distally.

The first dorsal vertebra is that one which is first connected with the sternum by a hæmapophysis. In genera with a well-developed sternum, the number of vertebræ anterior to the first dorsal is eight, except in the *Varanus niloticus* (Cuvier) and *V. griseus*, where it is nine. In the extinct Dolichosauria of the Cretaceous period, the cervical vertebræ are stated by Owen to number seventeen.

The number of ribs attached to the sternum diminishes with the reduction of the limbs, from the normal number of four on each side to one, and total disconnection. A common hæmapophysis or "xiphoid rod," succeeds these on each side, which gives attachment to two separate hæmapophyses for ribs. The common hæmapophysis is a segmentation of the anterior part of the fifth hæmapophysis, and it is not distinct in some genera, as *e. g.*, *Sauromalus*. In *Heloderma*, the fifth hæmapophysis has no sternal segment or connection, and the sixth is wanting. In *Varanus* the fourth, fifth and sixth are wanting. In genera with the two appendicular hæmapophyses, they are closely appressed on the middle line in the majority of the genera, but in genera of depressed form, they are separated often widely. They are separated in *Stenodactylus guttatus*, in *Phymaturus*, *Crotaphytus* and *Sceloporus*. They are more widely separated in *Dipsosaurus*, and most widely in *Sauromalus* and *Phrynosoma*. Cervical ribs are present in varying numbers, and the posterior ones are generally quite elongate. In certain genera and families the ribs posterior to those attached to the sternum have their hæmapophyses fused on the middle line below, thus constituting a series of abdominal ribs. In the Iguanid genus *Scartiscus* there are two such ribs. In the Anolidæ there are four and five pairs; in the Polychroine Iguanidæ there are seven to ten. In the Chamæleonidæ and Geconidæ there are several pairs. The ribs of *Lepidosternum* are remarkable for the presence of a capitular process, which has no distinct capitular articulation.

3. SCAPULAR ARCH.—The clavicle is present in all the families except the Chamæleonidæ, and in certain genera with degenerate fore limbs. In such genera it is the last portion of the scapular arch to remain, and it is

the only element present in *Feylinia* (Anelytropsidæ). It is always osseous. The form of its proximal extremity varies in the different families. It is simple in the *Nyctisaura*, *Uroplatoidea*, *Acrodonta*, *Iguania*, *Diploglossa* and *Thecaglossa*; and expanded and generally perforate in the other superfamilies where present, except in some degenerate genera where it is simple (see Plate ii, Fig. 2). In *Trachysaurus* and *Cophias*, its proximal end is dilated but not perforate. The scapula varies in form from elongate to short and wide. It presents a proscapular process in many families and genera. It is present in *Iguania* and *Nyctisaura*; in the last named often decurved and acuminate; and in *Lophura*, in *Acrodonta*. It is present among *Leptoglossa* in *Cnemidophorus*, and in some *Amivæ*, while in other *Amivæ* it is wanting. It is wanting generally in *Acrodonta*, *Diploglossa*, *Thecaglossa* and *Leptoglossa*, but it is present in *Celestus striatus*. It is wanting in *Rhaptoglossa*. The coracoid is extended anteriorly to the sternum, and it is generally deeply emarginate on its anterior interior border. These emarginations are closed by the procoracoid, which extends to the middle line, and is only partially or not at all ossified. There are two coracoid emarginations in most *Iguania*; exceptions being the terrestrial genera *Urocentrum*, *Sceloporus* and *Phrynosoma*, and the *Anolidæ*. There are also two in *Varanidæ* and *Tiidæ*. The *Agamidæ* generally have but one, but *Uromastix* is an exception. There is but one in *Anguidæ* and *Scincidæ* (two in *Tiliqua*); and none in *Helodermidæ* and *Chamæleonidæ*.

The interclavicle is a very characteristic element in the *Lacertilia*. It is wanting in *Chamæleonidæ* and in some genera with fore limbs rudimentary or absent. It is a simple splint in *Helodermidæ* and some degenerate genera. In other families it has a transverse limb on each side, which may be anterior, producing the "anchor-shaped" form, or median, producing the "cruciform" type. It is anchor shaped in *Acrodonta*, *Iguania*, and *Thecaglossa*, and cruciform in *Diploglossa* and *Leptoglossa*. In *Nyctisaura* it is cruciform with the lateral processes wide at the base. The sternum is a broad subrhombic plate which articulates by its anterolateral borders with the procoracoid and coracoid, and by its posterolateral borders with the ribs. In genera with well-developed limbs its principal differences are seen in the nature of its fontanelles when present. In the *Agamidæ* there are two, and in most *Iguanidæ* there is one. Exceptions are the genera *Polychrus*, *Sauromalus* and *Dipsosaurus*, where there is no fontanelle. There is none in the *Anolidæ*. In *Tiidæ* and *Lacertidæ* it is present, but in *Scincidæ* it is mostly absent, exceptions being the North American species of *Eumeces*. The fontanelle is wanting in *Gecconidæ*, *Diploglossa*, *Helodermatoidea*, *Thecaglossa* and *Leptoglossa*, with the exceptions above noted. The single median fontanelle is frequently concealed by the median limb of the interclavicle. It is nearly divided in some species of *Sceloporus*.

4. THE PELVIC ARCH.—It is characteristic of the *Lacertilia* that the ilium is directed upwards and posteriorly, and that the obturator foramina

are well developed. The latter are only separated from each other by ligament or cartilage, which may sometimes contain some lime salt. It is produced posterior to the ischia in a triangular process, and less frequently into a similar one in front of the pubic symphysis. The pubic foramen is always present. The pectineal process is present except in *Geconidæ*, but it is rudimental in some forms, as *Phrynosoma*. The following table shows the forms of the pubis in twenty-three genera of different families :

I. Pubes uniting at an acute angle.

1. Pectineal process anterior..... *Chamæleon*.
2. Pectineal process median..... *Calotes*, *Draco*,
Iguana *Dipsosaurus* *Anolis*,
Gerrhonotus,
Tupinambis *Cnemidophorus*.
3. Pectineal process near acetabulum *Scincus*,
Lacerta,
Eumeces (rudimental).
4. No pectineal process..... *Gonyocephalus*.

II. Pubes uniting at an obtuse or very open angle.

1. Pectineal process median..... *Iguana* *Cyclura* *Crotaphytus*,
Histiurus.
2. Pectineal process near acetabulum..... *Agama*,
Phrynosoma *Sauromalus* *Sceloporus*,
Heloderma,
Varanus.
3. Pectineal process none..... *Gecko* (*Phrynosoma*, rudiment).

There is a tuber ischii in all of the genera which have come under my observation except *Varanus*. In *Heloderma* and some other forms it is small.

5. THE ANTERIOR LIMB.—The humerus is much alike in all *Lacertilia*, *Chamæleo* only presenting peculiarities. The proximal end is expanded nearly in one plane, and the middle portion of the flattened extremity forms the oval head. This is not distinctly isolated, except by the presence of articular surface, from the greater and lesser tuberosities which occupy the angles of the expansion. The shaft betrays no twist. The distal end is chiefly occupied by the condyles; but there are epicondyles, of which the internal is the more prominent, except in *Chamæleon*, where they are wanting. The condyles consist of an external rib and a medio-internal roller, which is generally bounded at the internal extremity by a tuberosity, which is, however, wanting in *Chamæleon*. The ulna articulates with the median roller, its external edge being beveled by the external rib. The head of the radius articulates with the external rib, having shifted from its primitive position on the inner side. It results from this that in pronation the radius crosses the ulna. There is a short ole-

craon except in Chamæleon. The ulna and radius have about an equal share in the carpal articulation, sometimes the ulna a little the greater.

The constitution of the carpus is very uniform in Lacertilia with developed anterior limbs, the principal diversity being displayed by the Chamæleonidæ. In all, we have in the proximal row three distinct elements, the radiale, intermedium and ulnare (= pisiforme), the latter mainly external to the ulna and directed posteriorly. Distal to the radiale and intermedium, and between them and the carpalia of the second row, is a single small centrale. There are five carpalia, each corresponding to a metacarpal. I have failed to find in any of the genera at my disposal any of the carpalia fused together or wanting. In Chamæleon, on the contrary, Cuvier has shown that there is no ulnare, and that the centrale and carpalia are fused into a single round median piece, to which the metacarpals are articulated. In all the normal Lacertilia the tendons of the flexors of the digits are combined on the palm, and the point of junction is occupied by a large flat sesamoid bone. The number of phalanges is also remarkably uniform. They number in each digit, commencing with the pollex, 2-3-4-5-3. The sole exception in the genera with well-developed extremities is Chamæleon, where the numbers are 2-3-4-4-3. This genus differs also from other forms in the shapes of the metacarpals. Normally they are cylindric and subparallel in position and united in a common integument; but in Chamæleon they are flattened, with expanded extremities, and divided into two bundles by a fissure, three within and two without, enabling the three inner digits to oppose the two outer round a branch of a tree. The number of digits in Lacertilia is normally 5-5, but reductions take place presenting variations from 4-5 to 1-1, the posterior limb usually displaying a lesser degree of degeneracy than the anterior, although not always.

6. POSTERIOR LIMB.—The femur differs from the humerus in having a distinct head, which is marked off from a trochanter. The former is not hemispherical as in Mammalia, but is somewhat compressed, and is oval in section. The trochanter is on the inferior anterior side of the head, or in the position of the little trochanter of the Mammalian femur. There is no great trochanter, nor third trochanter. The condyles of the femur are not as well defined as in the Mammalia, and the patellar groove is represented by a shallow concavity without lateral ridges. Patella none, with some exceptional rudiments, as in *Varanus*, *e. g.* In Chamæleo all the prominent features of the femur are toned down; the trochanter being represented by a ridge. The fibula is more slender than the tibia, and is larger distally than proximally, the reverse of what obtains in the tibia. The latter has no crest.

Like the carpus, the tarsus is very uniform in the Lacertilia, the sole important modification being exhibited by the Chamæleonidæ. There are two fused proximal elements, which are probably tibiale-intermedium and fibulare. They are only distinct in *Heloderma* among North American genera, but a trace of the suture is seen in *Varanus*. In most Lacertilia

there is then, but one bone of the proximal row, which is flat and wider than long. No centrale, and but two tarsalia, the third and fourth, the latter much the larger. The second metatarsal projects alongside of t. iii, so as to approximate the tibiale; its head is figured by Cuvier as a distinct bone, but he does not describe it as such. In *Chamæleon* there is a single proximal tarsal element, which is not flattened as in other lizards, and this articulates with a single subglobular tarsale, from which the metatarsals radiate.* The phalanges number, like those of the anterior foot, 2-3-4-5-3, in ordinary *Lacertilia*, and 2-3-4-4-3 in *Chamæleonidæ*.

PHYLLODACTYLUS Gray.

In their osteology the species of this genus conform strictly to the *Gecconid* type as already described. I have before me the skeleton of *P. tuberculosus*, from which the following description is derived. The premaxillary is single and has a long superior spine; inferiorly it has the posterior border emarginate. Nasals elongate, distinct, emarginate posteriorly for the frontal. Frontal single, rather narrow, completely under-arching olfactory lobes. Parietals distinct, wide, without pineal foramen, lying rather closely on supraoccipital, sending backwards the parietoquadrate arch, which encloses a small foramen with the exoccipital. Supraoccipital distinguished from exoccipital by suture. Prefrontal narrow, forming the preorbital border to the middle above; no lachrymal; jugal represented by a splint which extends from the prefrontal to the extremity of the maxillary on the superior surface of the latter. Postfrontal a rather wide V-shaped bone, its longest limb extending posteriorly more than half way to the base of the parietoquadrate arch. No postorbital. Quadrate with a single large, concave, external conch. Paroccipital in the usual position, splint-like.

Vomers in close contact throughout, with a common convex posterior border; an external longitudinal convexity of the inferior surface, and a groove on each side of the median suture, which divides a keel. Palatines short and wide, and with a longer vomerine than maxillary process, and curving downwards below the level of the vomers. Nareal orifices fissure-like except posteriorly and anteriorly, the external border with a dentate process of the maxillary bone directed posteriorly near the middle. Pterygoids much expanded anteriorly, forming with the ectopterygoids and palatines a thin plate, which closes up the palatine foramen; contracting rather rapidly posteriorly to the subcylindric rod-like portion. Eipterygoid extending from the pterygoid at the basiptyergoid process, and resting on the apex of the petrosal. Latter produced above

* Cuvier (*Ossements Fossiles*, ed. 1836, p. 93) describes a distinct tibiale and fibulare in *Chamæleo*, and figures them (Plate 245, Fig. 52). These are not represented by Boulenger (*Proc. Zool. Soc., London*, 1891, p. 118). They are in fact not distinct tarsal elements, but are the epiphyses of the tibia and fibula such as exist also in *Heloderma* and other genera. The tibiale and fibulare are fused into a single element as in other *Lacertilia*.

anterior to semicircular canal; the anterior border continued into a crest which runs posteriorly above the trigeminal foramen. This terminates at the down-looking crest of the subforaminal portion, which bounds externally a wide down-looking groove. Basipterygoid processes long. Sphenoid distinct from basioccipital. Occipital condyle subequally divided into three parts, two prominent exoccipitals and a contracted basioccipital. The result is an apparently double condyle.

Mandible with the Meckelian groove closed, and with the splenial small and but little produced beyond the splenial foramen. Coronoid produced a little horizontally at the base. Angular not distinct; surangular and articular distinct. Angle simple, direct, spoon-shaped, with superior concavity. I have observed the following peculiarities in the otic and hyoid regions. There is no infrastapedial cartilage, and the supratapedial and epistapedial cartilages are continuous. The hyoid system is characterized by the fact that the ceratohyal is attached to the paroccipital, which carries a cartilage on its extremity. There is a short second ceratobranchial, and no free epibranchial.

Vertebræ amphicelous. Intercentra present throughout the vertebral column, continued into chevrons on the caudal region. Cervical ribs widened and truncate at extremities. In the specimen described the diapophyses of the second sacral vertebra are deeply longitudinally grooved on the inferior side so as to be nearly split. Diapophyses of anterior caudals elongate. Neural spines distinct but low throughout the column. In the scapular arch I note the following peculiarities. There is no proscapula, and the clavicle is much enlarged, and is perforate at the median extremity. The interclavicle is cruciform with the angles filled up so as to have concave borders. It is coössified with the clavicle in *P. tuberculatus*, and extends but a little way posteriorly on the sternum. The coracoid has one large foramen. The sternum has no fontanelle. There are four hæmapophyses attached to the sternum on each side; and two to each of the slender closely approximated xiphoid rods. There are several very slender abdominal ribs.

The ilium has no *angulus cristæ*, and the acetabulum is entire. The pubes join at a little less than a right angle, and the pectineal processes are short and a little posterior to the middle. Pubes uniting at less than a right angle below, with the tuberosities distal.

The most distinctive feature of the skeleton of this genus is the presence of intercentra throughout the vertebral column, a point in which it resembles the extinct *Theromora* of the Permian epoch.

EUBLEPHARIS Gray.*

Owing to the isolated position of this genus its osteology is worthy of especial attention. The premaxillary is undivided, and has a long superior spine but no inferior spine. The nasals are distinct. The frontals

*I include in this genus the *Coleonyx* of Gray, which does not differ generically from the other American species of the family.

are coössified and the interorbital space is very narrow. The parietals are coössified and there is no pineal foramen. The supraoccipital is loosely articulated anteriorly, but is coössified with the exoccipitals. No lachrymal bone; prefrontal large but not reaching far posteriorly over orbit. Postfrontal small, crescentic; no postorbital. No postorbital or supratemporal arches. Parietoquadrate arch depressed; paroccipital lying over the parietal at the inferior extremity. No jugal bone. No orbitosphenoid; the olfactory lobes enclosed below by the frontal bone. Petrosal produced beyond semicircular canal at the superior anterior angle, and without the oblique crest such as is characteristic of the *Geconidæ*. A subforaminal projection and groove, the external wall of the groove as prominent downwards as the internal, so that the groove is open inferiorly. Vomers swollen, separated for most of their length by a deep groove. Palatines short and wide, sending a postnares process to the maxillary. Pterygoids broad and flat in front, narrower posteriorly, with a short ectopterygoid without descending angle, enclosing a maxillopalatine foramen. Basipterygoids elongate. Sphenoid and basioccipital distinct; the latter distinct also from exoccipitals. Occipital condyle convex, without exoccipital portion. Epipterygoid oblique, articulating below posterior to ectopterygoid process of pterygoid and above with petrosal only. Quadrate straight, oblique, with a single conch, which is external to the rod-like axis; condyle emarginate. In the mandible the angular bone is small but distinct, and the coronoid is produced much further anteriorly than posteriorly on the external face of the ramus. The dentary extends to about opposite the middle of the coronoid on the external face of the ramus. The splenial extends posteriorly but not anteriorly. The Meckelian groove closed. In the hyoid apparatus all the elements are present, including a pair of elongate second ceratobranchials. There is a free process of the ceratohyal anterior to its junction with the hyohyal.

The scapular arch is much like that of the *Geconidæ*. The clavicle is expanded and perforate proximally. The interclavicle is subcruciform with the limbs connected by laminate expansion. There is a small proscapula which is connected at its apex with the epicoracoid. Coracoid with one large emargination. Sternum without fontanelle, supporting three ribs and a ziphoid rod, which supports but one rib. No abdominal ribs.

ANOLIS Daudin.

The following osteological description is taken principally from the *A. carolinensis*, but other species which I have examined do not differ from it.

Premaxillary with long superior spine, and no inferior spine, but a notch. Nasals distinct, separated by premaxillary spine. Frontal and parietal bones each undivided, the pineal foramen on the coronal suture. Prefrontal large, not extending over orbit; lachrymal narrow, in contact with jugal. Postfrontal small, distinct; postorbital large. Supratem-

poral slender, forming the greater part of the supratemporal arch, its anterior extremity in contact with the postorbital and postorbital process of jugal bones. Paroccipital small; parietoquadrate arch well developed. Supraoccipital loosely attached, coössified with exoccipital.

The frontal bone is grooved on the median line below. The postoptics are within the epipterygoids, and are curved, enclosing a subcircular space, and have a short external branch. The epipterygoid leaves the pterygoid behind the ectopterygoid process, and articulates with the parietal, passing some distance in front of the petrosal. The petrosal is very short above; the subforaminal process is distinct, and the inferior groove looks outwards as well as downwards. Quadrate with wide external conch and no internal conch. Stapes not deeply sunk; columella slender. The vomers are flat and elongate, and are not separated by a groove. The palatines are broad and flat, and the maxillopalatine foramen is small. The pterygoids are broad and flat in front, and are then abruptly contracted from the outside to a narrow posterior part. This curves outwards from the long basipterygoid processes to the quadrate. The ectopterygoids are short and are deflected at the proximal extremity. Presphenoid long and rod-like. Occipital condyle convex, simple, without exoccipital divisions.

The mandible has marked peculiarities. The Meckelian groove is closed, and the splenial bone, if present, is minute. I do not detect it in the *A. carolinensis*. There is a fossa on the inside of the ramus at the base of the coronoid. The latter bone is developed much anterior to its apex on the external face, and not posteriorly. The dentary is produced far posterior to the coronoid. The angular and articular are fused, and the angle is rather short and has an internal angular projection (*Xiphocercus valenciennii*, *Anolis equestris*, *A. marmoratus*, *A. carolinensis*).

The hyoid apparatus has the extreme development seen in all the lizards with a gular compressed pouch or fan. That is, the ceratobranchials of the second pair are closely appressed and produced to a great length. First pair of ceratobranchials and ceratohyals simple, the latter attached to the extremities of the moderately developed hypohyals.

The scapular arch conforms to the Iguanid type. There is a proscapula well above the coracoid, and a single coracoid notch. The sternum has a small median fontanelle which is reached by the long posterior limb of the interclavicle. Two ribs attached to each side of sternum, and three to each of the slender, closely appressed xiphoid rods. There are five pairs of abdominal ribs in *Anolis carolinensis*, and four, five and six in other species.

The vertebræ have no zyosphe nor elongate diapophyses. There are eight cervical vertebræ, of which only the last four have ribs, all of which have simple heads, the last two being elongate and reaching to the plane of the sternum.

The caudal vertebræ have no supplementary dividing suture, and there

is but one neural spine. The chevron bones are attached at the extremity of the centrum.

The pubes unite at an acute angle, and have well-developed pectineal process at the middle of their length. The ischia have a prominent tuber.

The premaxillary and anterior maxillary teeth are simple; the others are tricuspid.

DIPSOSAURUS Hallow.

The osteology of this genus presents a number of interesting peculiarities which constitute difference from *Crotaphytus*, to which its general appearance suggests affinity.

Premaxillary bone with elongate superior spine, and posterior emargination of inferior face. Nasals large, distinct, not shortened in front, since the nostrils open forwards. Frontal narrow, entire, grooved on the middle line below, its posterior region pierced by the pineal foramen which is entirely anterior to the coronal suture (*D. dorsalis*). Supraoccipital loosely articulated anteriorly, and not distinct from exoccipitals. Prefrontals large, not extending over orbit; lachrymal smaller, touched by jugal. Postfrontal small, distinct from the large postorbital. The latter articulates extensively with both the jugal and supratemporal. Paroccipital small. Parietoquadrate arch well elevated. The vomers together as broad as long, not produced posteriorly, with a median fossa. Palatine flat, with a short maxillary process; pterygoid flat in front, concave on the inner side behind for contact with the long basiptyergoid process. Ectopterygoid decurved at its inner extremity. Quadrate with a narrow internal and a wide external conch. Postoptic an open sigmoid, reaching frontal above, with a median expansion with rudiment of posterior limb. Petrosal very short above; subforaminal portion prominent, with a wide inferior groove looking downwards. Epiptyergoid leaving pterygoid behind ectopterygoid process, and reaching parietal without contact with petrosal. Presphenoid rudimental; sphenoid and basioccipital united, and with prominent lateral edges. Occipital condyle with exoccipital elements feebly distinguished.

In the mandible the Meckelian groove is completely curved. The coronoid has little horizontal extent, and that is principally anteriorly on the external side. The surangular and articular are fused together, and the splenial is small. The dentary extends as far posteriorly as the posterior border of the coronoid. The angle is prominent, flattened so as to be horizontal, and has an internal angle.

The scapula has a large proscapula directed upwards, and the coracoid has one emargination, which is large. The sternum has a narrow median fontanelle which is not covered by the interclavicle. There are four pairs of ribs articulated to the sternum, and two continue into the approximated xiphoid rods. The ribs reach the sacrum.

Vertebrae with a zygosphen articulation. Eight cervical vertebrae, the anterior with a compressed hypapophysis, which soon becomes a keel, which is absent on the eighth cervical and all following vertebrae. Four anterior vertebrae without ribs; seventh and eighth with long ribs. Diapophyses very short, except in the caudal region, where they are present for half its length, increasing in length to the base where they are quite elongate. Chevron bones intercentral. Neural spines of dorsal region low, of caudal region rather elevated, oblique, and preceded by a compressed vertical prominence or anterior neural spine. The centra are transversely segmented just in front of the diapophysis, except in the anterior part of the series.

The angle of junction of the pubes is nearly right, and the pectineal process is median, short and decurved. The ischia have a long common suture, and are deflected downwards, meeting at less than a right angle. Tuber a prominent angle. The ilium presents a short subacute angle representing the *crista*. There is a deep posterior notch of the acetabulum.

In *Dipsosaurus dorsalis* all the teeth on the maxillary bone are tricuspidate; those on the premaxillary are mostly simple, but one or two external ones show a rudimental lateral cusp.

CROTAPHYTUS Holbrook.

The skeletons of the two most abundant species are before me, viz., the *C. collaris* Holbr. and *C. wislizenii* B. & G. The following description includes both, and if any differences between the two exist, they are mentioned.

The premaxillary has a long spine above and a concave border behind on the palate, from which projects forwards a pair of juxtaposed processes which together form a button-like process which has an anterior free border. The nasals are wide and shortened by the removal of their anterior border on account of the large size and partly vertical direction of the nostrils. Frontal single, narrow; pineal foramen touching coronal suture, in the frontal bone in *C. collaris*, and in the parietal in *C. wislizenii*. Prefrontal large, with a prominent preocular boss, not extending posteriorly over the orbit. Lachrymal small in line with and touching the jugal. Postfrontal wanting; its place taken by a process of the frontal. Postorbital large, uniting exteriorly with jugal and supratemporal. Parietoquadrate arch elevated; supraoccipital bone loosely articulated, not distinct from exoccipital. Quadrate with rather flat conchs, the external the larger, and with straight external border. Postoptics not reaching frontal, curved, with short posterior branch. Petrosal with prominent subforaminal portion which has an open groove looking downwards. Vomers short and wide, not separated by a groove. Palatines flat, with short maxillary process. Pterygoids rather narrowed by the large palatine foramina; posterior part grooved and receiving basi-

pterygoid processes. Ectopterygoids depressed internally. Epipterygoid originating behind ectopterygoid process, and reaching parietal without contact with petrosal. Presphenoid rudimental; sphenoid and basioccipital confluent. Occipital condyle plain, with exoccipital elements not distinct. The fenestra ovale and foramen of viii nerve sunk in deep fossæ.

In the mandible the terminal part of Meckel's cartilage is exposed. The coronoid has no extension on the external face, and extends a short distance forwards on the inner face. The splenial is rather elongate, and extends anterior to the splenial foramen. The dentary extends to the line of the posterior border of the coronoid above, and of its anterior border below. In old individuals the surangular and articular are fused. The angle is pinched, and sends inwards a horizontal process similar to its posterior process.

In the hyoid apparatus the ceratobranchials of the second pair are closely appressed, thus supporting a median gular angle. The hypohyals are moderately long, and they join by their extremities the ceratohyals, which have no expansions, and are of only moderate length.

The scapula has a well-developed proscapula, and there are two deep emarginations of the coracoid. The sternum has a narrow longitudinal median fontanelle in the *C. collaris*, and no fontanelle in *C. wislicenii* (one specimen of each examined). There are four ribs articulating directly with the sternum on each side, and two via each xiphoid rod. The latter are not closely appressed as in some, nor so widely separated as in other Iguanidæ.

Vertebræ without zygosphenal articulation, but the prezygapophyseal faces concave. Cervical vertebræ eight, the anterior five vertebræ with six free intercentra in *C. wislicenii*, and four vertebræ with five intercentra in *C. collaris*, anterior three vertebræ without ribs in both species. The neural spines are very low on the dorsal vertebræ, and are a little more elevated on the caudals. The latter have a projecting keel towards the anterior part in the *C. wislicenii* (wanting in *C. collaris*), which represents the anterior neural spine of *Dipsosaurus dorsalis*. The centra in *Crotaphytus* are not segmented. Diapophyses are present, but are nowhere long. Short ribs extend to the sacrum.

The teeth are tricuspid, but in the two species examined the lateral cusps are rudimental. Anterolateral and incisor teeth simple, subequal.

The pubes unite at an exceedingly open angle, and the pectineal process is submedian. Tuber ischii prominent; a small angle or crista ilii. Acetabulum entire posteriorly.

The principal characters in which the skeleton of the *Crotaphytus* differs from *Dipsosaurus* are the following: Nasal bones shortened in front; no postfrontals; pineal foramen connected with coronal suture; Meckelian canal partly open; two notches of coracoid; xiphoid rods not appressed; no zygosphen; caudal centra not divided; acetabulum not deeply notched.

SAUROMALUS Duméril.

The following description of the osteology of this genus is based on a skeleton of the *S. ater*, belonging to the National Museum.

The premaxillary has a long spine above and a transverse posterior border below with the anteriorly directed button process. The nasals are well developed and distinct in spite of the large size of the nares. Frontal entire, rather narrow, grooved on the middle line below, and including pineal foramen, which touches the coronal suture. Parietals divided perhaps abnormally in specimen. Supraoccipital loosely attached, but fused with exoccipitals. Prefrontals large, not extending over orbits; lachrymals small, in contact with jugal. Postfrontal distinct, small. Apex of postorbital cartilaginous, inferior face in long contact with jugal and supratemporal. Paroccipital not large; parietoquadrate arch well separated from exoccipital. Postoptic not reaching frontal, superior extremity expanded backwards and forwards. Petrosal very short above, prolonged below, inferior groove looking laterally. *Fenestra ovale* and *foramen nervi octavi* sunk in deep fossæ. Vomers entirely separated from maxillaries, not produced, but separated by a groove behind. Palatines with a short maxillary process. Palatine foramen moderate; pterygoids divaricating from each other outwards. Ectopterygoid produced downwards at the posterointernal angle. Pterygoids grooved from basiptyergoids backwards on internal side. Quadrate with two conchs, the internal one flat. The epistapedial cartilage is largely ossified.

Presphenoid a slender rod; sphenoid and basioccipital confluent. Occipital condyle with exoccipital elements slightly marked above.

In the mandible Meckel's cartilage is completely enclosed. The splenial is produced but little beyond the splenial foramen. Coronoid extended a little anteriorly at base on external face of ramus, and a little further on the inner side. Dentary extending as far back as coronoid. Articular and surangular distinct.

The premaxillary and anterior maxillary teeth are simple; the other maxillaries have two or three denticles anteriorly and one posteriorly. In the dentary bone the teeth (except in front) have two denticles on each edge.

The hyoid apparatus displays a pair of parallel but separate second ceratobranchials about half as long as the first ceratobranchials. Ceratohyals slightly expanded proximally, articulated at end of moderately long hypohyals.

The vertebræ display a zygosphenal articulation. Five cervicals display free intercentra, and four of them have no ribs. Ribs extending to sacrum. The two sacral centra and diapophyses are distinct, but the second diapophysis has a median longitudinal groove. Caudal centra of the distal half of the tail segmented, and possessed for the middle of the length of double diapophyses, between which the fissure passes. Diapophyses long on basal third of tail. Neural spines low everywhere; on the caudal vertebræ they stand at the posterior end, and send a keel to

the anterior end, where it is elevated into a low anterior spine. Chevron bones intercentral. Four sternal ribs and two from the xiphoid rod.

Scapula very short, with a large superior proscapula. Coracoid with two notches. Sternum wide and emarginate posteriorly, spreading the xiphoid rods far apart. No fontanelle.

Pelvis with the pubis transverse and the pectineal process external. Ischia rather slender, with a short symphysis, and each with a long tuberosity.

This genus is remarkable for the combination of characters it displays. The zygosphenal articulation allies it to *Dipsosaurus* and the larger *Iguanidæ*, but the separated ceratobranchials, and the wide sternum are like that of the *Phrynosomas*, with the exception of the fontanelles. The transverse pubes have a similar significance.

SCELOPORUS Wiegmann.

As a basis for an examination of the osteology of this genus I have before me two skeletons of the *S. undulatus* and one of the *S. spinosus*, from the National Museum.

The premaxillary bone has a long superior spine, and is truncate on the palatal face, and has the button-like process. The nostrils are partially vertical so that the nasals are a little shortened in front. The latter are rather large and are distinct. The frontal is simple and narrow, and is strongly grooved on the middle line below. The parietal is short and wide, and is perforated by a large pineal foramen which touches the coronal suture. Parietoquadrate arch distinct. Supraoccipital broadly but loosely attached, confluent with exoccipitals. Prefrontals large, not reaching postfrontals above; lachrymal small and joining jugal. Postfrontal a small splint; postorbital large, extensively in contact with jugal and supra-temporal. Paroccipital small. Vomers short, divaricate and separated by a deep notch behind. Palatine with the vomerine process longer than the maxillary; palatine foramen large. Palatines and pterygoids well separated from each other on the middle line; ectopterygoid deflected at its internal extremity. Basipterygoids developed. Quadrate with two conchs, the internal the narrower. Presphenoid rudimental; sphenoid and basioccipital coössified; descending lateral processes of the latter strongly developed. The supraforaminal part of the petrosal is very short; the infraforaminal portion is produced beyond it and is nearly horizontal in position. The *foramen nervi octavi* is at the bottom of a fossa. Epipterygoid resting on pterygoid much posterior to ectopterygoid and reaching parietal without touching petrosal. Occipital condyle not subdivided by grooves.

The hyoid system includes a pair of well-separated short second ceratobranchials, and rather long and slender first ceratobranchials and ceratohyals, which have no expansions. Hypobranchials moderate, supporting ceratohyals at extremities.

Mandible with Meckel's cartilage exposed at the distal part. Coronoid

not horizontally produced on external face. Articular and surangular united. Splenial moderately elongate; dentary extending behind coronoid on external face and deeply notched. Angle short, horizontal, with short internal angle. Five cervicals with intercentra in *S. undulatus* and six in *S. spinosus*; three without ribs in both. Ribs extending to sacrum. Sacral centra not coössified. Sacral diapophyses coössified distally; the second with a posterior free angle distally. Caudal diapophyses well developed at base of tail. From about the eighth caudal the centra are segmented in front of the middle.

Scapula with proscapular process; coracoid with one notch. Sternum with a very large fontanelle. Two ribs join the sternal plate; one comes off the base of the xiphoid rod, and two articulate with the latter; total, five pairs. The ilium has a small *angulus cristæ*, and the acetabulum is not emarginate behind. The pubes are nearly transverse, and the pectineal angle is external. The ischia are rather slender, and the tuber is an angle.

The middle and posterior teeth are feebly tridentate; the others are simple.

PHRYNOSOMA Wiegmann.

The following account of the osteology is derived from the skeletons of three species, the *P. douglassii*, *P. cornutum* and *P. coronatum*. The description applies equally to each of these species unless otherwise stated.

The premaxillary has a very short alveolar portion which does not bound the nostrils below (or very little *P. coronatum*). It has a superior spine and concave palatal border. The nasals are distinct and are excavated in front by the large nareal openings. The frontal is single, is much narrowed in front by the prefrontals, but extends transversely posterior to the orbits, where it sends forwards an acute process in the superciliary angle. The prefrontal is large and extends posteriorly to or beyond the middle of the supraorbital border. It sends posteriorly an acute superciliary process, which meets that of the frontal from behind, over the eye in *P. cornutum*; does not quite meet it in *P. coronatum*, and fails to meet it by a longer interval in *P. douglassii*. The lachrymal is small and is not reached by the anterior angle of the jugal. The parietal is broad and short, and the pineal foramen pierces it at the coronal suture. Its lateral border is very little decurved to meet the petrosal.

Its strong parietoquadrate arch supports a horn or tuberosity, and in most of the species the middle of the posterior border supports the same. The occipital is broadly articulated with the parietal in *P. douglassii* and *P. coronatum*; in the former loosely, in the latter closely. In *P. cornutum* it affords a narrow but firm support for the parietal. Paroccipital small, visible from behind. The postfrontal is visible as a rudiment in *P. douglassii*, but it is apparently coössified in the two other species. The postorbital is slender, expanding below for union with jugal and supratemporal. The former bears two sharp tuberosities in *P. coronatum*, and the supratemporal two. In *P. cornutum* there is none on the jugal but there

are three on the supratemporal; and in *P. douglassii* the arrangement is similar. Owing to the inferior position of the supratemporal, the quadrate is oblique forwards and downwards. It presents one conch, the external. The vomers are short, and are separated from each other for the posterior half or more of their length by a hiatus, which continues posteriorly of about equal width between the palatine and pterygoid pairs. The latter are short, wide and flat, and the palatine foramen is small; least and oval in *P. coronatum*; small and round in *P. cornutum*; larger and elongate in *P. douglassii*. The ectopterygoid is decurved at its inner extremity. The presphenoid is wanting, and the suture between the sphenoid and the basioccipital is persistent. The supraforaminal part of the petrosal is very short, and the infraforaminal part is not much produced, and has a wide inferior groove. The epipterygoid originates behind the ectopterygoid process, and has the peculiarity among Iguanidæ of not reaching the parietal, but of resting on the anterior border of the petrosal. The occipital condyle shows traces of its tripartite composition. The postoptic is curved and simple and does not reach the frontal bone. The latter is grooved on the middle line below.

The groove of Meckel's cartilage is open throughout in *P. cornutum* and *P. coronatum* and distally only in *P. douglassii*. The coronoid is not produced horizontally on the external face of the mandible, and the dentary is not produced beyond its posterior border. This element has a reflected inferior border in the *P. cornutum* which is acutely dentate posterior to the middle; characters absent from *P. coronatum* and *P. douglassii*. In *P. douglassii* the surangular is not coössified with the articular, while it is so united in the other two species. The angle is short, and is directed downwards and obliquely inwards.

The basihyal is wide and is ossified, and the second ceratobranchials are very short and widely separated. The hypohyals are short and carry the ceratohyals on their extremities. No expansions of lateral elements.

The vertebræ have no zygosphen articulation, but the prezygapophyseal facet is carried upon the side of the neurapophysis at an angle with the usual position. This furnishes the initial step in the production of a zygosphen. I find five cervical intercentra in *P. cornutum* and *P. coronatum*, and six in *P. douglassii*, exclusive of the intercentrum of the atlas, which has no hypapophysis. Ribs extend to the sacrum, and are attached to very short diapophyses. The two sacral diapophyses are separated by a wide fissure in the *P. coronatum* and *P. douglassii*, but are closely appressed in *P. cornutum*. On one side of the skeleton of *P. douglassii* the last lumbar vertebra carries, abnormally, a third sacral diapophysis which reaches the ilium. Proximal part of caudal vertebræ with long diapophyses. Caudal centra not segmented. Chevron bones intercentral, *not uniting distally*. Neural spines everywhere very low, those of the caudal vertebræ single.

The suprascapula is exceptionally elongate, and the scapula is of moderate length and has a proscapular process. The coracoid has one emar-

gination. The interclavicle is remarkable for the shortness of its posterior limb, which is shorter than the transverse limb in *P. cornutum* and *P. douglassii*, and equal to it in *P. coronatum*. The sternum has a very large fontanelle which approaches the posterior border. In *P. coronatum* and *P. douglassii* three ribs articulate with the sternum, but in *P. cornutum* two only in my skeleton. The xiphoid rods are widely separated, and carry but one rib.

The ilium has a short *angulus cristæ*, and the acetabulum is entire. The pubis and ischium are slender and transverse in position, and approach nearly at their symphyses, which are connected by a short, narrow cartilage. The pectineal process is obsolete, while the tuber ischii is a prominent angle.

Two peculiarities especially distinguish this genus among Iguanidæ: first, the connection of the epipterygoid with the petrosal; and, second, the absence of symphysis of the chevron bones. The characters of the sternum are an extreme of what is seen in Sceloporus.

GERRHONOTUS Wieg.

A skeleton of the *G. multicarinatus* from the U. S. National Museum, furnishes the material for an osteology of this genus.

The premaxillary has a well-developed spine and a truncate palatal border. Its alveolar border is short, and it forms but a small part of the inferior nareal border. Nasal bones not short in front, rather narrowed by the maxillary and prefrontals on each side. Frontal narrow, single, partly enclosing olfactory lobes of the brain below, but the incurved lateral walls not touching. Parietal with small pineal foramen far behind coronal suture. Supraoccipital loosely articulated, and separated by suture from exoccipitals. Prefrontal not tuberiferous, produced posterior to middle of supraorbital border. Postfrontal crescentic equally united with frontal and parietal. Postorbital splint-shaped, with very slight contact with the jugal, and long contact with the supratemporal. Jugal slender, reaching anteriorly the small lachrymal. Paroccipital narrowly exposed posteriorly, well produced upwards on the distinct parietoquadrate arch. Quadrate with one deeply excavated conch, which is external. Vomers in close apposition in front, separated by a fissure posteriorly; the anterior portion excavated medially. Palatines descending from the plane of the vomers, the vomerine and maxillary processes about equal; main plate rather narrow. Palatine foramen large. Pterygoid contracting gradually into posterior slender portion; basipterygoid well developed. Presphenoid wanting. Sphenoid and basioccipital separated by suture; descending tuberosities of the latter strong, compressed. Epipterygoid originating below opposite basipterygoid; above resting on anterior process of petrosal, and touching parietal just behind an obtuse descending angle of the decurved border of the same. Subforaminal portion of petrosal shorter than supraforaminal portion, en-

closing a very narrow down-looking groove. Basioccipital and exoccipitals coössified; condyle small, simple.

Meckel's canal closed except distally, where it is open on the *under side* of the ramus. Coronoid developed anteriorly on external face of ramus, the dentary not reaching behind its anterior border. Splenial elongate, partly external; angular mostly external; surangular confluent with articular. Angle horizontal incurved with rounded border and concave superior surface.

Hyoid apparatus displays no second and rather short first ceratobranchials. Hypohyal rather long, the ceratohyal extending a little beyond its extremity, and widened at the posterior third. A free epibranchial which has a bifurcate anterior extremity at that of the ceratohyal, and extends posteriorly but little behind the ceratobranchial.

Five cervical intercentra, and two cervicals besides atlas without ribs. The odontoid is coössified with the axis. Ribs extend to sacrum. Sacral diapophyses distinct from each other. Dorsal vertebrae without zygosphen, prezygapophyseal facets not continued on neural arch. Caudal diapophyses present; centra of middle region segmented through them; chevron bones intercentral. Neural spines low, higher on caudal region.

Suprascapula much larger than scapula; no proscapula. One large coracoid notch. Sternum without fontanelle, with three ribs and two attached to xiphoid rod.

Ilium without prominent *angulus cristæ*; acetabulum entire; pubes uniting at an acute angle; pectineal angle medium. Ischia with prominent tuber.

CNEMIDOPHORUS Wiegmann.

For characters of the skeleton I have three individuals of the *C. tessellatus* from my own, and one of the *C. sexlineatus* from the National collection. The alveolar portion of the premaxillary is prominent, and is marked off from that of the maxillary bone by a shallow emargination on each side. The superior spine is long, and the palatal border is deeply emarginate to receive the narrow anterior production of the vomers. The nasals are distinct and rather elongate, although encroached on in front by the enlarged nostrils. The frontal is single and is rather narrow. The parietal is without pineal foramen in the adult. The parietoquadrate arch is well elevated, and is braced below by the small paroccipital. The supraoccipital is in close contact with the parietal by its middle portion, and it is distinct from the exoccipital by suture. The prefrontal does not extend above the orbit; the lachrymal is smaller, but rather large, and forms a suture with the jugal. The postfrontal is wanting, being fused with the postorbital. The latter is produced downwards and has a longer suture with the supratemporal than with the narrow jugal. The quadrate has an external conch only. The vomers are elongate and are in contact throughout, but each is swollen on the middle line so that they are divided by a

groove along their common suture. The nareal fissure is long and narrow, and is contracted anteriorly, and then enlarged foramen-like at the anterior extremity. The vomerine branch of the palatines is longer than the maxillary branch; the pterygoid branch is not very wide, and the palatine foramen is of moderate size. The ectopterygoid is rather wide and has an anterior suture with the palatine bone as well as with the maxillary; it is deflected posteriorly. Pterygoid moderately expanded anteriorly and contracting gradually; the posterior portion but slightly grooved, and attached to the basiptyergoid process by its entire width, and not by the groove only. Presphenoid rudimental; sphenoid distinguished from basioccipital by suture; the latter with descending compressed lateral processes. Petrosal with a short presemicircular process, and a long subforaminal process; the latter presenting an open groove downwards. Inferior face of frontal grooved; postoptic not reaching frontal, triradiate, the two superior limbs shorter than the inferior. Epiptyergoid arising opposite ectopterygoid and in contact with a descending lateral process of the parietal and not touching petrosal.

The hyoid apparatus is distinguished, like that of other *Tiidae*, by the great prolongation of the hypophyals anterior to the point of attachment of the ceratophyals. No second ceratobranchials or free epibranchials.

In the mandible the Meckelian groove is closed except at the distal portion. The coronoid is produced far anteriorly and not at all posteriorly on the external face, and the dentary does not extend much beyond the tooth line. Surangular distinct; angle horizontal, expanded, and forming an angle inwards. A distinct masseteric fossa, bounded below by the angular. Splenial elongate, extending far anterior to the splenial foramen.

Teeth with the crowns moderately compressed and unequally bicuspid; those of premaxillary and adjacent part of maxillary bone and corresponding part of mandible, simple.

Dorsal vertebræ with zygosphen. In both *C. tessellatus* and *C. sexlineatus* there are five cervical intercentra besides that of the atlas, and the first rib is on the third or fourth vertebra. Two sacral diapophyses, both robust. Neural spines distinct, moderate, highest in the caudal series; ribs extending to sacrum. Diapophyses very short except in caudal region, where they extend for a considerable part of the length, originating posterior to the middle of the centrum. On the distal part of the caudal series there is an additional short spine-like diapophysis in front of the normal one, and the centrum is segmented between the two. The segmentation disappears anteriorly with the disappearance of this pre-diapophysis. Chevrons intercentral.

The suprascapula is of moderate dimensions and extends to the summit of the neural spine. Scapula elongate, and with a large proscapula. Coracoid with two deep notches. Interclavicle with a very long median limb, which is wide at the base and which covers an elongate oval median fontanelle. Three sternal ribs, and two attached to the xiphoid rod.

Ilium with a prominent *angulus cristæ*. Acetabulum entire; pubis di-

rected anteriorly at an acute angle, with median pectineal angle. Ischia directed vertically downwards, with *angulus tuberosus*, and pre- and post-ischiadic acuminate cartilages.

It is remarkable that in the large species of the allied genus *Tupinambis* the proscapular process is wanting.

XANTUSIIDÆ.

In addition to the characters which I have previously given, Mr. Boulenger states (*Catal. Brit. Mus.*) that the sternum is without fontanelle. I find the hyoid apparatus has characters somewhat similar to those of the Lacertidæ. The ceratohyals and second ceratobranchials are both present and there is a well-developed free epibranchial. Its proximal end overlaps the distal end of the second ceratobranchial. It passes round the extremity of the first ceratobranchial and extends forwards. In *Lepidophyma* it has the peculiarity, which I have not seen in any other lizard, of being inserted on the lateral process of the basioccipital. In *Xantusia riversiana* (Plate vi, Fig. 41) it terminates before reaching this point. In *Lepidophyma* it displays a concave expansion as it passes the extremity of the first ceratobranchial, in which lies the helicoid cartilaginous extremity of the latter. In neither genus are the hypohyals prolonged with the ceratohyals, as in Anguidæ, nor beyond them as in the Tiidæ.

The stapedial disk in *Lepidophyma* is not sunk in a canal as in the Iguanidæ and some other Lacertilia. The columella is slender, and terminates in the interstapedial cartilage. This supports an oblique cartilaginous rod, one end of which (suprastapedial) is attached to the osseous wall above, and the other longer one (epistapedial) is in contact by a flat surface of its extremity with the membrum tympani (Plate v, Fig. 26).

The remarkable characters of the skull in *Xantusia* are described under the head of that genus. Bocourt (*Mission Sci. de Mexique*, Pl. xxg, Fig. 2), represents a probably similar structure in *Lepidophyma*.

XANTUSIA Baird.

My knowledge of the osteology of this genus is derived from the *X. riversiana*, specimens of which I owe to my friend, Dr. J. J. Rivers, of Oakland, Cal.

The *os premaxillare* has an elongate spine above and a nearly transverse posterior border below. Nasals well developed, distinct. Frontal single, grooved below. Parietal single, without pineal foramen, produced posteriorly so as to overhang the occipital bone and foramen magnum; being connected with the former by a median keel which it sends downwards. The supraoccipital is subhorizontal and is not articulated in the usual way with the parietal, having only the median contact above mentioned. It is coössified with the exoccipitals. The prefrontal is small and is not produced far over the orbit. Lachrymal absent. Jugal with the super-

posterior limb expanded. Postfrontal and postorbital fused into a triangular bone which bounds the parietal externally, thus, with the supratemporal, roofing over the temporal fossa. Supratemporal in contact throughout with the parietal except where separated by the narrow splint of a paroccipital. Quadrate with one, a large external conch. Vomers closely juxtaposed throughout, coössified anteriorly, the median portion of the two elements with an excavation. Nareal orifices nearly closed except posteriorly, where the vomerine process of the palatine overarches them. The latter are in contact in front but soon spread apart. Maxillary processes rather shorter than vomerine, depressed below them. Pterygoids narrow throughout, not wider than palatines, their posterior part with a groove which looks upwards and inwards. Basipterygoids overlapping their entire internal face. Ectopterygoids wide, reducing the palatine foramen to a mere slit; with a considerable contact with the palatine, and a recurved portion in contact with the extremity of the maxillary; the internal extremity depressed. No presphenoid; sphenoid separated by suture from basioccipital, whose lateral processes are compressed and decurved. The postoptic bone seems to be wanting. The petrosal is well produced beyond the semicircular canal, and is equally produced below the trigeminal foramen, where it joins a backwards directed process of the basipterygoid. The groove below it is well defined and looks downwards. The epipterygoid rises at the basipterygoid and rests on the anterior border of the petrosal and the posterior border of the well-marked descending process of the parietal. Fenestra ovale not sunk in the fundus of a fossa.

The mandible is remarkable in having but three bones. The articular, angular and surangular are coössified, and the splenial and dentary. The coronoid has little horizontal production on the outside of the ramus, and the angle of the dentary extends considerably posterior to it. The Meckelian groove is entirely closed.

The hyoid apparatus is described under the head of the genus *Xantusia*.

There is no zygosphe. There are six cervical intercentra besides that of the atlas. The cervical ribs commence on the fourth vertebra. Four of these ribs are of peculiar form, being expanded and truncate at the extremity so as to be somewhat fan-shaped. Neural spines rather low on the cervical and caudal regions, and lower on the dorsal vertebræ. Caudal vertebræ segmented towards the anterior part, the fissure passing through the middle of the diapophyses. Neural spine single, oblique, posterior; chevron bones normal.

Suprascapula short and wide; scapula without proscapula. Coracoid with one notch; sternum without fontanelle. Interclavicle with moderate posterior limb. Sternal ribs three; xiphoid rods not juxtaposed, supporting two ribs. No abdominal ribs.

Pubes meeting at about a right angle; pectineal angles near the middle, decurved. Pubis with tuber exterior. Ilium without angulus cristæ; acetabulum entire.

The teeth have compressed tridentate crowns; those of the premaxillary bone are not conic, but have also compressed crowns, where traces of denticles are sometimes apparent.

The remarkable features in the osteology of this genus are (1) the peculiar relations between the parietal and supraoccipital bones, which resemble the structure seen in a sea-turtle; (2) the wide ectopterygoid; (3) the absence of lachrymal; (4) the presence of only three mandibular elements. The affinities are a mixture of those of the Lacertidæ and Scincidæ; the large postfrontal bones; the descending processes of the parietals, and the form of the pubes, resembling the corresponding parts in the latter family. The expanded cervical ribs resemble those of the Geconid genus Phyllodactylus. The relations of the parietal and occipital bones are quite different from those found in the Lacertidæ and Anguidæ (*Gerrhonotus*, *Celestus*, *Ophisaurus*), where the temporal fossæ are also roofed over. In these forms the contact is normal, *i. e.*, by the elevated median portion of the anterior border of the occipital.

EUMECES Wiegmann.

For the determination of the skeletal characters of this genus I have skeletons of the *E. obsoletus* and *E. fasciatus*, from the National collection.

The premaxillary is split as in other Scincidæ, and the halves are in the closest contact. The common spine is rather elongate, while the palatal suture is simply emarginate. The nasals are not shortened, and are distinct. The frontal is double, and is simply grooved on the middle line below. The parietal is single, and is pierced by the pineal foramen at about its middle. The parietoquadrate arch is well elevated. The supraoccipital is loosely articulated, presenting a truncate median process towards, but not to, a median notch of the parietal. Exoccipital distinct by suture. Prefrontal rather large, not sending posteriorly a superciliary process, and not produced far above the orbit. Lachrymal small; not, or very little visible on external facial surface, and reached by a long internal process of the jugal. External surface of jugal separated widely from prefrontal, its postorbital portion much longer, slender, and rising to meet the postfrontal. The latter is large and unequally V-shaped, the posterior limb broad and covering the temporal fossa between the parietal and supratemporal bones, with more or less of a fissure next the parietal posteriorly. Postfrontal a splint separating the jugal and supratemporal from the postfrontal. Supratemporal well produced anteriorly, and in contact with the parietoquadrate arch for the posterior two-thirds the length of the latter. Quadrate with one, a deep external conch. The vomers are elongate, and also expanded laterally, passing above the prominent palatine laminae of the maxillary bones. They are in close apposition on the median line, but are so swollen longitudinally as to leave a groove at the common suture. The longitudinal ribs terminate in a pair of appressed hooks which look downwards and backwards at the posterior extremities of the bones. The vomerine branch of the palatine

is not quite as long as the maxillary branch, and is on a superior plane, being in close contact with its mate on the middle line, and forming with the maxillary plate a half tube opening inwards. Pterygoids not very wide, gradually narrowing to the posterior rod which is openly grooved on the inner side. The basiptyergoid processes overlap the entire width of the internal face. Ectopterygoid reaching maxillary and jugal, but not palatine; little deflected posteriorly. Presphenoid not ossified; sphenoid distinguished from basioccipital by suture. Latter with subconic descending lateral processes, which enclose a deep fossa on the external side. Postoptic small, simple, crescentic. Petrosal extended well in advance of semicircular canal above; subforaminal portion still more produced bounding a down-looking open groove. Parietal sending downwards a rather elongate process in front of petrosal. Epiptyergoid originating opposite basiptyergoid below, and resting above on the descending process of the parietal and the anterior margin of the petrosal. Occipital condyle tripartite.

Meckel's cartilage exposed from the anteriorly placed splenial foramen. Coronoid a little produced anteriorly on external face of ramus, not at all posteriorly. Surangular and articular distinct; angle flat, rounded, not produced or angular inwards. Dentary produced as far posteriorly as coronoid; splenial rather elongate (forming the inferior border of Meckel's groove in *E. obsoletus*).

In the hyoid system, *E. fasciatus* presents a short second ceratobranchial. The first ceratobranchial has a cartilaginous terminal segment, as has also the ceratohyal. The latter is of moderate length, is without expansions, and is articulated with the extremity of the rather short hypobranchial. There is a large free epibranchial, which commences near the free extremity of the second ceratobranchial, and curving backwards, outwards and then forwards, terminates nearly opposite the middle of the ceratohyal.

The cervical intercentra in the *E. obsoletus* number four, and those of the *E. fasciatus* three, posterior to that of the atlas. There is no zygosphen. The caudal diapophyses are well developed at the base of the series, and are split lengthwise at the middle and distal part of the series by the segmentation of the vertebræ. Neural spine single at posterior extremity of neural arch.

The suprascapula is expanded anteroposteriorly, and the scapula is rather elongate. The latter has no proscapula, while the coronoid has one emargination. The sternum has a small fontanelle posteriorly placed. There are three costal articulations and a xiphoid rod with two ribs. The latter is in close apposition to its mate, and is expanded outwards at the junction of the first hæmapophysis.

The ilium has no *angulus cristæ*, and the acetabulum is entire. The pubes converge at a subacute angle, and the small pectineal process is nearer the proximal extremity, and is turned downwards. The ischia are subtransverse, and present a wide emargination posteriorly, since the *processus tuberosus* is near the acetabulum.

Besides the family characters, this genus is well distinguished among American lizards by the divided frontal ; the overroofing the temporal fossa by the postfrontal and supratemporal ; the descending process of the parietal ; forms of the xiphoid rods, and forms of the pelvic bones.

ANNIELLA Gray.

My observations on this genus are based on specimens from San Diego, Cal., presented to me by my friend, James S. Lippincott.

The premaxillary has an elongate spine, and the palatal suture presents backwards two concavities separated by a median projection. The nasals are distinct and rather short and wide. The frontals are distinct and rather wide. The parietal is very large everyway, is single, and has no pineal foramen. The supraoccipital forms a close suture with it, sending forwards a median process for internal gomphosis, and an angle on each side of it. It is coössified with the exoccipital, and is expanded to accommodate the large circle of the superior semicircular canal. The facial plate of the maxillary is large. The prefrontal is above the eye, and is cut off from the postfrontal by an entrant angle only. The lachrymal is small, and is below and separated from the prefrontal. No jugal. Postfrontal crescentic, bounded by both frontal and parietal. Postorbital a caducous scale lying in contact with the posterior limb of the postfrontal. Petrosal with its superior border in close contact with the decurved lateral borders of the parietal, as in a snake. The latter do not, however, descend to the presphenoid, but leave a wide fissure below it which deeply notches the anterior border of the petrosal. Supraforaminal part of petrosal produced to an acute angle, terminating at the parietal border much in advance of the anterior semicircular canal. Body of petrosal perforated by a large foramen just in front of the superior part of the quadrate. No parietoquadrate arch, but a posteroexternal angle of the parietal extending near to the proximal extremity of the quadrate. No distinct supratemporal or paroccipital. Stapes with large disk and short stout columella, with thickened tympanic extremity. Vomers continuous anteriorly, slightly divergent posteriorly ; excavated by a deep groove posteriorly, which terminates in a fossa medially. The external borders of the posterior apices are turned outwards so as to enclose partially the posterior nares below. The palatines are short, the groove separating the maxillary from the vomerine processes extending to the suture with the pterygoid, so that the maxillary process only appears as the inferior face of the bone. Pterygoids elongated anteriorly, reaching to beyond the middle of the palatine foramen. They extend directly back to the quadrates, being well separated on the middle line, and abruptly notched on the inner side to receive the short angular basipterygoids. They are separated from the sphenoid by a fissure, and are grooved on the inner side posterior to the basipterygoid. Ectopterygoids present, rather slender, enclosing rather large palatine

foramina. No epipterygoid. Nareal fissure overhung by the free edge of the maxillary and palatine bones. Sphenoid and basioccipital and exoccipital coössified. Occipital condyle convex and perfectly simple.

The mandible has an open Meckelian groove, and the surangular and articular bones are coössified, while the angular and splenial bones are distinct. The latter extends well anteriorly. The coronoid extends a little forwards on the exterior face of the ramus, and in both directions on the inner face.

The hyoid apparatus is the most simple among lizards. It consists of a continuous cartilaginous glossobasilhyal rod, which is bifurcated posteriorly; and a simple osseous first branchiyl, attached to each of the branches. Other elements wanting.

Ten cervical vertebræ with compressed inferior processes of the centra or hypapophyses. They are coössified with the centra, and are not intercentral in position, hence it is not evident that they are intercentra. No zygosphe. In the *Anniella pulchra* there are seventy-three rib-bearing vertebræ, and two cervicals without ribs. The sacral and proximal caudal vertebræ have diapophyses, those of the former little different from those of the latter. The fifth vertebra with a diapophysis supports a pair of parallel plates coössified with its inferior face like the chevron or double hypapophysis of a snake. In the succeeding vertebræ similar plates form the basis of a chevron, whose symphysis is turned rather abruptly posteriorly. The position of these chevrons is central and not intercentral. Caudal vertebræ not segmented.

Scapular elements and fore limb wanting. Pelvic arch represented by a pair of slender simple bones which lie near the extremities of the last ribs, one on each side of the vent. They are slightly curved, and are well separated in front. They are very similar to the bones which occupy the same position in the *Amphisbænida*, and are probably the iliopectineal bones of *Fürbringer*. Teeth simple, acutely conic.

The affinities of the *Anniellidæ*, as indicated by the above description, are interesting. When I first, in 1864,* pointed out the cranial peculiarities of the genus *Anniella*, I created for it a distinct family, which I associated with the *Acontiidæ* and *Anelytropsidæ*. Subsequently, in 1887,† I proposed for it a still more independent position, making it the type of a special superfamily, which I called the *Anguisauri*; a course which had been already adopted by Gill a short time previously,‡ who proposed for it the superfamily of the *Annielloidea*. The further knowledge of its structure above recorded brings out more clearly its true position. This is, I think, in the *Annulati* or *Amphisbænia*. The characters which indicate this reference are: (1) The continuity of the parietal with the petrosal and supraoccipital elements. (2) The absence of epipterygoid. (3) The absence of ceratohyal elements. (4) The hypopophyses of the

* Proceedings Academy Philada., 1864, p. 230.

† Bullet. U. S. Natl. Museum No. 32, p. 25, 1887.

‡ Smithsonian Report, 1886, The Progress of Zoölogy for 1885, p. 40.

cervical vertebræ which are continuous with the centra. (5) The partially open chevron bones, which are also continuous with the centra. (6) The sublongitudinal ileopectineal bone and absence of other pelvic elements.

There is agreement in various subordinate features, as the single premaxillary, double frontal, and single parietal; and the absence of supratemporal bone; also the fusion of the surangular and articular bones. There are some differences to be noted. Thus, in some of the *Amphibænia* at least, there is apparently an orbitosphenoid bone, which is wanting in *Anniella*. The pterygoid is more closely adherent to the basis cranii in the *Amphibænia*, and there is no palatine foramen, which is present in *Anniella*. The splenial is of full size in *Anniella* and the Meckelian groove is open. In the *Amphibænia* the groove is closed and the splenial is much reduced.

The presence of scales, the papillose tongue and the distinct tegumentary eye fissure, with the characters above cited, define the *Anniellidæ* as a very distinct family of the *Amphibænia*.

RHINEURA Cope.

A specimen of the *R. floridana* Baird from Volusia, Fla., furnishes the characters of the skeleton.

The alveolar border of the premaxillary is very short, and supports only one, a median tooth. The spine is divided into two portions, that below the projecting angle of the muzzle and that above it. The former is contracted a little by a process of the maxillary which enters from the alveolar portion, separating it from the nostril, which is inferior in position. It then expands a little, to form on the upper side of the muzzle a terminal expansion twice as wide as long. The nasals are distinct, and extend to the border of the muzzle, overroofing the nostrils. Frontals wide, distinct, deeply emarginate posteriorly for the parietal. Prefrontal rather large, triangular, sending its apex posteriorly over the orbit and reaching the parietal. Its free border and a narrow band of the parietal form a *crista temporalis*, which do not unite on the middle line into a *crista sagittalis*. Parietal single, without pineal foramen, continuous laterally with the petrosal and alisphenoid, and posteriorly with the supraoccipital, from which it receives on the middle line a gomphosis. Supraoccipital bounding foramen magnum, of which it forms a rather narrow border. A small triangular bone at the extremity of the maxillary may be a jugal or a lachrymal. The alisphenoid and petrosal form the inferior part of the side walls of the brain case, and are separated from the pterygoids and presphenoid below them by a narrow fissure which is widest below the petrosal. The latter sends an angle upwards and backwards between the parietal and exoccipital. The exoccipital sends a prolongation (paroccipital ?) downwards and forwards, which gives articulation to the quadrate, bounding the fenestra ovale above. The latter is large and is closed by the large disk of the stapes. The quadrate has no posterior

proximal process, and is oblique proximally, but is more nearly vertical distally. In its posterior angle rests the club-shaped head of the robust *columella auris*.

The vomer presents as its anterior extremity a process which separates a transverse process from each maxillary, and enters a notch in the posterior border of the premaxillary. The vomers are plane in front but become convex and separated by a fissure posteriorly, ending each in an acuminate apex lying on the presphenoid. The palatine is narrow and lies along the inner side of the ectopterygoid, consisting chiefly of its maxillary process; it is doubtful whether it possesses a vomerine process. Posteriorly it lies scale-like on the pterygoid, reaching nearly to the line of the quadrate (Pl. i, Fig. 5, B pl.). The nareal fissure is nearly closed anteriorly, except a foramen-like portion at the anterior extremity. The presphenoid, sphenoid and basioccipital are coössified. To these the pterygoid is closely appressed by the one side, while on the outer side the latter carries the narrow splint-like ectopterygoid as far as the maxillary. No palatine foramen. Occipital condyle simple, transverse, medially concave.

The mandible displays no Meckelian groove, and the splenial is small. The small angular is only visible on the internal side of the ramus. Surangular and articular confluent. Coronoid large, triangular, not concave below, and overlaid at base externally by anterior extremity of surangular; anteriorly not extended over dentary. Angle short, longer than wide, a little inflected, simple; its plane an angle of 45° to that of the ramus.

The hyoid apparatus is very simple. It consists of a glossobasihyal cartilage which is deeply bifurcate posteriorly. At the posterior extremity each posterior limb sends a process forwards, which is about half as long as the anterior elements, the hypohyal. No ceratohyal nor second ceratobranchial. A rather short and simple osseous first ceratobranchial on each side.

The vertebral column consists of many cervico-dorsals and a relatively small number of caudals. The second vertebra has a strong keel-like hypapophysis, which is also strong on the third, but which diminishes from that point so that on the sixth it is no longer perceptible. The first rib is short and is attached to the third vertebra. Diapophyses and neural spines very short. The ribs do not display a vertical process at the head as in *Lepidosternum octostegum*. Diapophyses very short and simple on caudal vertebræ. Caudal hypapophyses commencing on the anterior fourth of the caudal series, at first the halves widely separated. They soon converge downwards, and finally touch, but are never coössified to form a chevron. Position on the middle of the length of the centrum. Rib-bearing vertebræ without trace of zygosphen.

Scapular arch absent. Pelvic arch represented by a single curved rod on each side of and anterior to the vent, which is connected with the extremities of two ribs by ligament only. This is the ileopectineal bone of Fürbringer. No trace of posterior limb.

Teeth simple, conic ; situated on premaxillary, maxillary and dentary bones only. Premaxillary with but one, a median tooth.

The genus *Lepidosternum*, as typified by the *L. octostegum*, differs from *Rhineura* in that the nasal bones are excluded from the nareal borders by the maxillary, and from contact with each other by the prolonged spine of the premaxillary. In both of these points *Rhineura* agrees with *Amphisbæna*. In *Lepidosternum* also there is a Meckelian groove, and the angle is turned vertically downwards. In *Amphisbæna (fuliginosa)* there is a groove and no angle.

PLATE II.

Figs. 1-3. *Feylinia currorii* Gray ; $\times 2$; from Gaboon, West Africa ; specimen in Museum Academy Natl. Sciences, Philadelphia.

Fig. 1. Skull, three views ; 2, skeleton of pectoral region ; 3, skeleton of sacro-pelvic region.

Fig. 4. *Anniella pulchra* Gray ; skull, $\times 3$; from San Diego, California ; from specimen in my private collection presented by Mr. James S. Lippincott.

Fig 5. *Rhineura floridana* Baird ; skull, $\times 3$; from Volusia, Fla. ; from specimen in my private collection from Mrs. A. D. Lungren.

The principal characters of the osteology of the *Feylinia* and *Anniella* I described in the *Proceeds. Academy Philadelphia*, 1864, pp. 228-230 ; and the pelvic arch of the latter and of *Rhineura* in a paper now in press in the *American Journal of Morphology*. Additional characters of all the above forms are described in the preceding pages.

Lettering.—*Pmx.*, premaxillary ; *N.*, Nasal ; *F.*, frontal ; *P.*, parietal ; *So.*, supraoccipital ; *Mx.*, Maxillary ; *Pef.*, prefrontal ; *L.*, lachrymal ; *J.*, jugal ; *Pof.*, postfrontal ; *Pob.*, postorbital ; *Pofb.*, postfrontoörbital ; *St.*, supratemporal ; *Pio.*, paroccipital ; *Ex.*, exoccipital ; *Os.*, orbitosphenoid ; *Pop.*, postoptic ; *Epg.*, epipterygoid ; *Pe.*, petrosal ; *Q.*, quadrate ; *Stp.*, stapes ; *V.*, vomer ; *Pl.*, palatine ; *Pg.*, pterygoid ; *Ecp.*, ectopterygoid ; *Sp.*, sphenoid ; *Bo.*, basioccipital ; *Art.*, articular ; *Co.*, coronoid ; *Ang.*, angular ; *Spl.*, splenial ; *D.*, dentary ; *Cl.*, clavicle ; *R.*, rib ; *S.*, sacrum ; *Pv.*, pelvis.

PLATE III.

Hyoid bones of Lacertilia.

Fig. 1. *Sphenodon punctatum* Gray ; nat. size ; from specimen presented by Sir James Hector.

2. *Chamaeleon* sp. ; from Cuvier ; nat. size.

3. *Gecko verticillatus* Laur. ; nat. size ; from Cuvier.

4. *Aristelliger præsignis* Hallow. ; nat. size ; dissected and drawn by Dr. E. E. Galt.

- Fig. 5. *Phyllodactylus tuberculatus* Wieg. ; $\times 2$; dissected and drawn by Dr. E. E. Galt.
6. *Thecadactylus rapicaudus* Houtt. ; $\times 2$.
7. *Eublepharis elegans* Gray ; $\times 2$; Dr. Galt.
8. *Eublepharis variegatus* Baird ; $\times 2$.
9. *Calotes cristatellus* Kuhl ; nat. size.
10. *Phrynocephalus mystaceus* Pallas ; nat. size.
11. *Uromastix hardwickii* Gray ; nat. size ; from the Zoölogical Garden of Philadelphia.
12. *Holbrookia maculata* Gir. ; $\times 2$; from specimen from Otto Lerch, San Angelo, Tex.

PLATE IV.

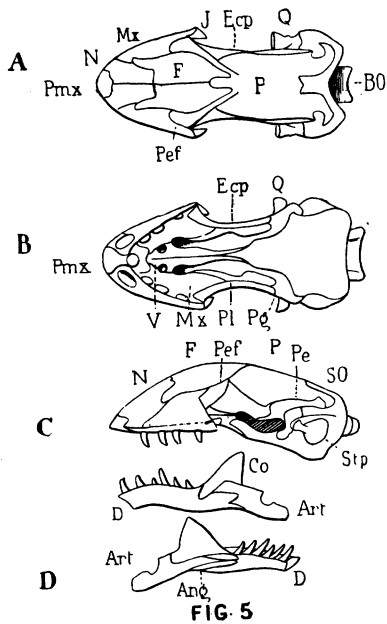
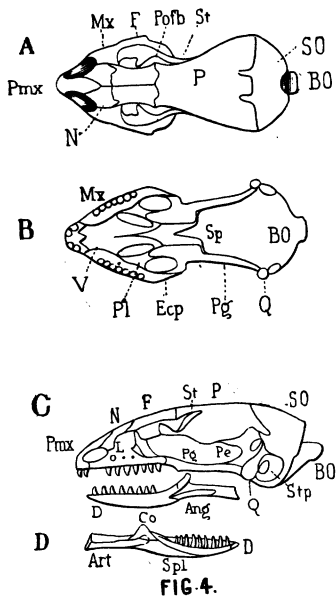
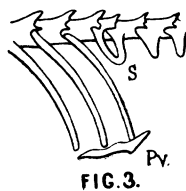
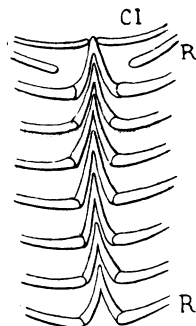
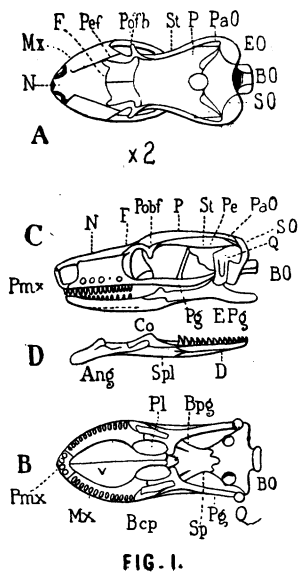
- Fig. 13. *Phrynosoma coronatum* Blv. ; $\times 3$; Dr. Galt.
14. *Sceloporus undulatus* Daud. ; $\times 2$.
15. *Uta stansburiana* B. & G. ; $\times \frac{5}{2}$.
16. *Sauromalus ater* Dum. ; nat. size.
17. *Crotaphytus wislicenii* B. & G. ; $\times 2$.
18. *Anolis carolinensis* D. & B. ; $\times 2$.
19. *Ctenosaura teres* Harl. ; nat. size (not adult).
20. *Iguana tuberculata* Laur. ; from Cuv. ; nat. size.
21. *Anguis fragilis* L. ; $\times 4$; from Northern Italy.
22. *Dracæna guianensis* Daud. ; nat. size ; from specimen from Zoölogical Garden, Philadelphia.

PLATE V.

- Fig. 23. *Gerrhonotus multicarinatus* Blv. ; $\times 2$; Dr. Galt.
24. *Ophisaurus ventralis* Daud. ; $\times 2$; Dr. Galt.
25. *Heloderma suspectum* Cope ; nat. size ; Dr. Galt.
26. *Xenosaurus grandis* Gray ; $\times 2$.
27. *Varanus niloticus* Linn. ; nat. size ; Dr. Galt.
28. *Scincus officinalis* Laur. ; $\times 2$; from Cuvier.
29. *Eumeces fasciatus* L. ; $\times 3$; Dr. Galt.
30. *Egernia cunninghamii* Gray ; nat. size ; the ends of the ceratobranchials are cut off in the specimen.
31. *Liolepisma laterale* Say ; $\times 2$; from Hidalgo, Mexico (*L. gemmingeri*).
32. *Gonyylus ocellatus* Forsk. ; $\frac{3}{2}$.

PLATE VI.

- Fig. 33. *Celestus striatus* Gray ; nat. size.
34. *Gerrhosaurus nigrolineatus* Hallow. ; $\times 2$.
35. *Zonurus cordylus* Linn. ; $\times 2$.
36. *Mancus macrolepis* Cope ; $\times 3$.
37. *Xantusia riversiana* Cope ; $\frac{3}{2}$ nat. size.
38. *Lepidophyma flavomaculatum* Dum. ; three times nat. size.
39. *Psanmodromus algirus* Linn. ; $\times 2$.



1-3, *Feylinia currorii*. 4, *Anniella pulchra*. 5, *Rhineura floridana*.

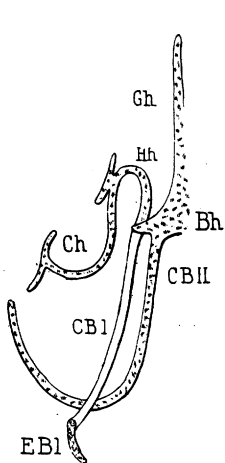


FIG. 7.

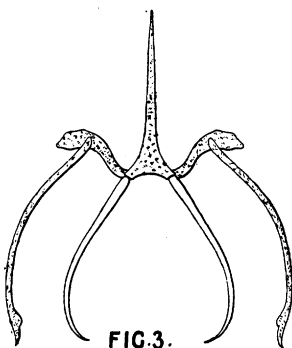


FIG. 3.

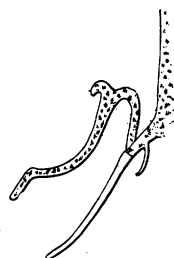


FIG. 4.

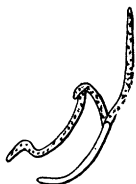


FIG. 5.

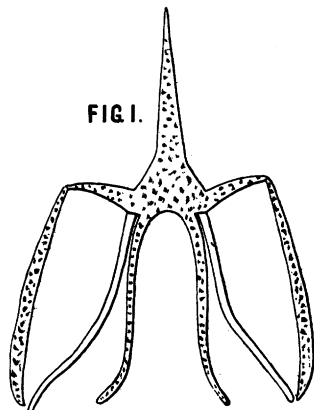


FIG. 1.

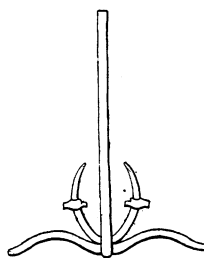


FIG. 2.

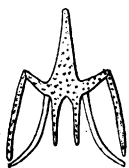


FIG. 10.

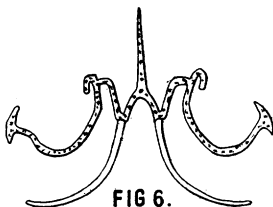


FIG. 6.

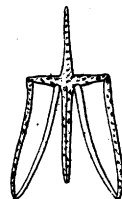


FIG. 9.

FIG. 12.

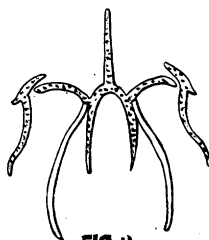
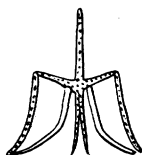
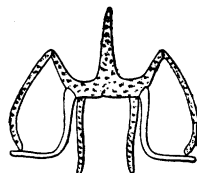


FIG. 8.

FIG. 11.



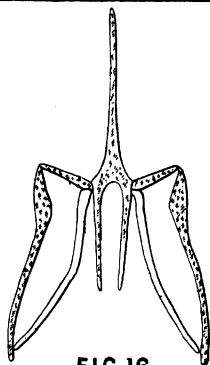


FIG. 16.

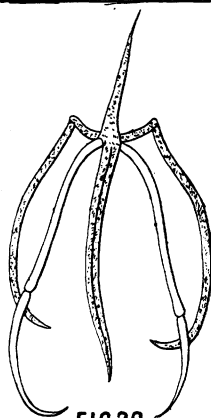


FIG. 20.

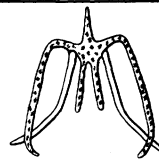


FIG. 14.

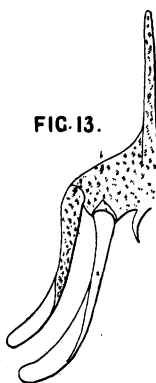


FIG. 13.

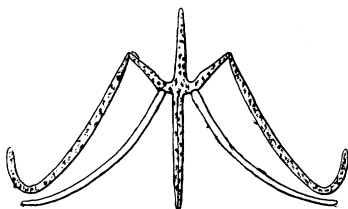


FIG. 19.

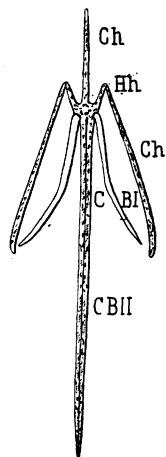


FIG. 18.

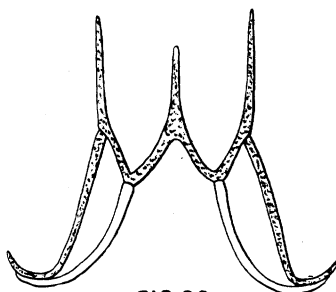


FIG. 22.

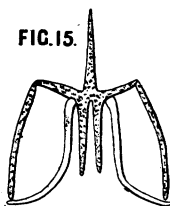


FIG. 15.

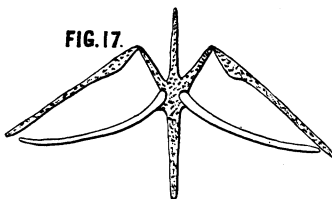


FIG. 17.

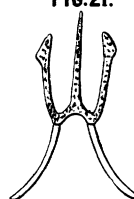


FIG. 21.

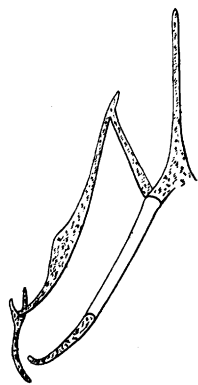


FIG. 23.

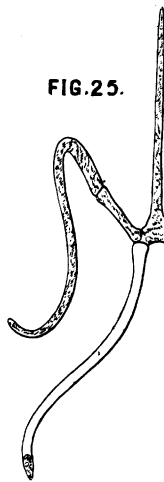


FIG. 25.

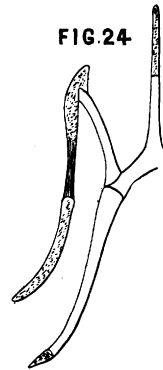


FIG. 24.

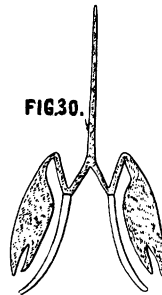


FIG. 30.

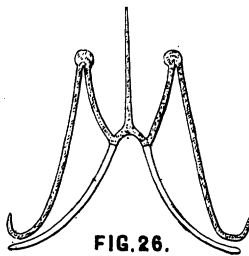


FIG. 26.

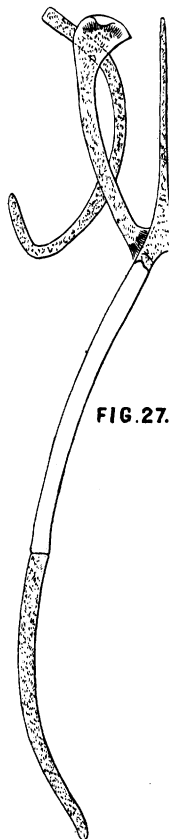


FIG. 27.

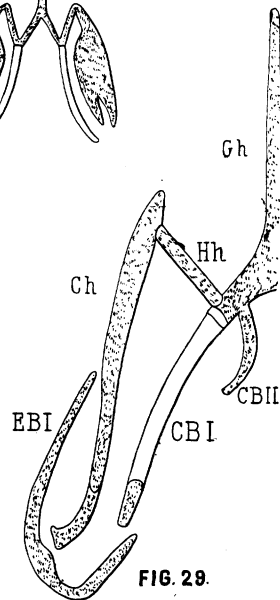


FIG. 29.

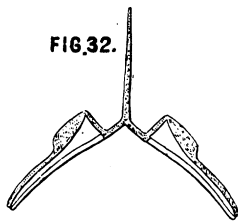


FIG. 32.

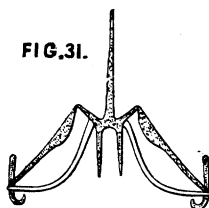


FIG. 31.

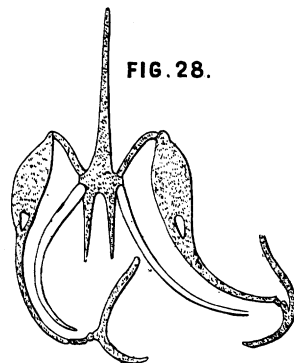
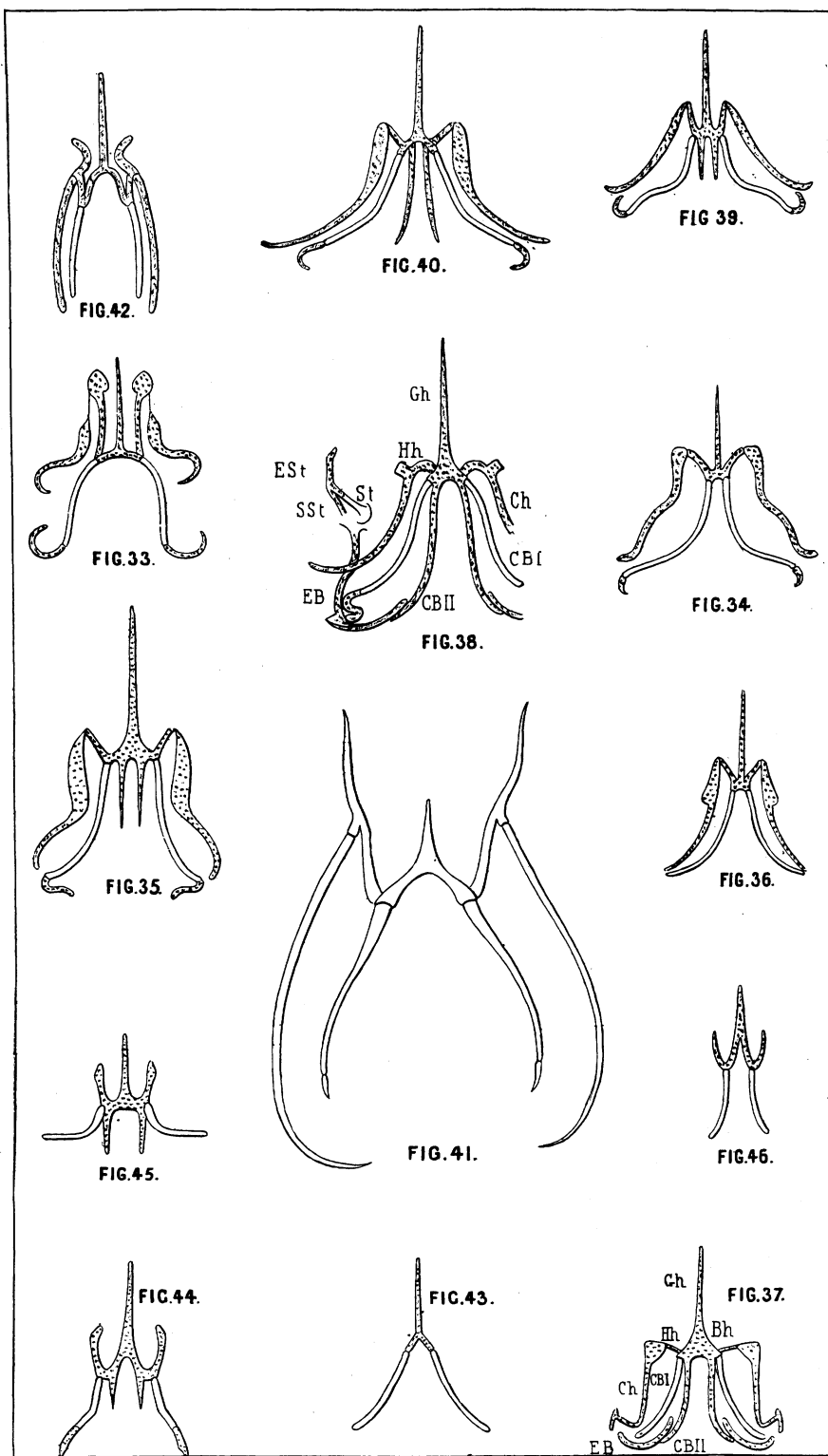


FIG. 28.



- Fig. 40. *Lacerta ocellata* Daud. ; nat. size.
 41. *Tupinambis teguixin* Daud. ; nat. size ; from Cuvier.
 42. *Onemidophorus tessellatus* Say ; $\times 2$.
 43. *Anniella pulchra* Gray ; $\times 4$; from specimen from James S. Lip-pincott.
 44. *Chirotos canaliculatus* Bonn., $\times 4$.
 45. *Amphisbæna alba* Linn. ; $\frac{2}{3}$ nat. size.
 46. *Rhineura floridana* Baird ; $\times 4$.

Lettering.—*Gh.*, glossohyal ; *Bh.*, basihyal ; *Hh.*, hypohyal ; *Ch.*, ceratohyal ; *CB. I.*, first ceratobranchial ; *CB. II.*, second ceratobranchial ; *EB.*, epibranchial ; *St.*, stapes ; *E. St.*, epistapedial ; *S. St.*, suprastapedial.

ERRATA.

Page 211, line 16, for 41 read 37.

Page 211, line 27, for Plate v, Fig. 26, read Plate vi, Fig. 38.

Page 216, lines 25-30. This description of the pelvis of *Anniella* is erroneous. I describe it in a paper in press in the *American Journal of Morphology*, and not having the MS. with me when the present paper was written, trusted to memory, and confused it with the pelvis of *Feylinia*.

On Some New and Little Known Paleozoic Vertebrates.

By E. D. Cope.

(*Read before the American Philosophical Society, April 1, 1892.*)

It has been long known that the Catskill-Chemung beds of Northern Pennsylvania contain a fish bed rich in specimens. This deposit has been traced from Warren, on the west, to Susquehanna county, inclusive, on the east. It is now known that at the close of the Chemung epoch, as at the close of the Devonian in Belgium and Scotland, land emergences took place, producing more or less continued brackish and fresh-water conditions. The latter received the deposits known as the Catskill in the Eastern United States, and their alternations with Chemung beds containing Chemung invertebrate fossils are now well established as facts of our geological history. A recent visit to Tioga and Bradford counties, in Pennsylvania, has recently afforded me the opportunity of inspecting some of the localities where vertebrate fossils occur. These have been already referred to by Prof. J. S. Newberry in his work on the Paleozoic fishes of North America. Guided by two geologists residing in the regions in question—Mr. Andrew Sherwin, of Mansfield, Tioga county, and Mr. A. T. Lilley, of Leroy, Bradford county—I had an excellent opportunity of observing the mode of occurrence of the fossils and of obtaining specimens. I wish here to express my particular indebtedness to these gentlemen for the aid they have rendered me.

The locality I visited, near Mansfield, is typical Catskill. The list of species obtained is not large. They are :

Bothriolepis nitidus Leidy. *Holonema rugosum* Clayp. *Ganorhynchus*